OCTOBER 2, 1958

MACHINE DESIGN

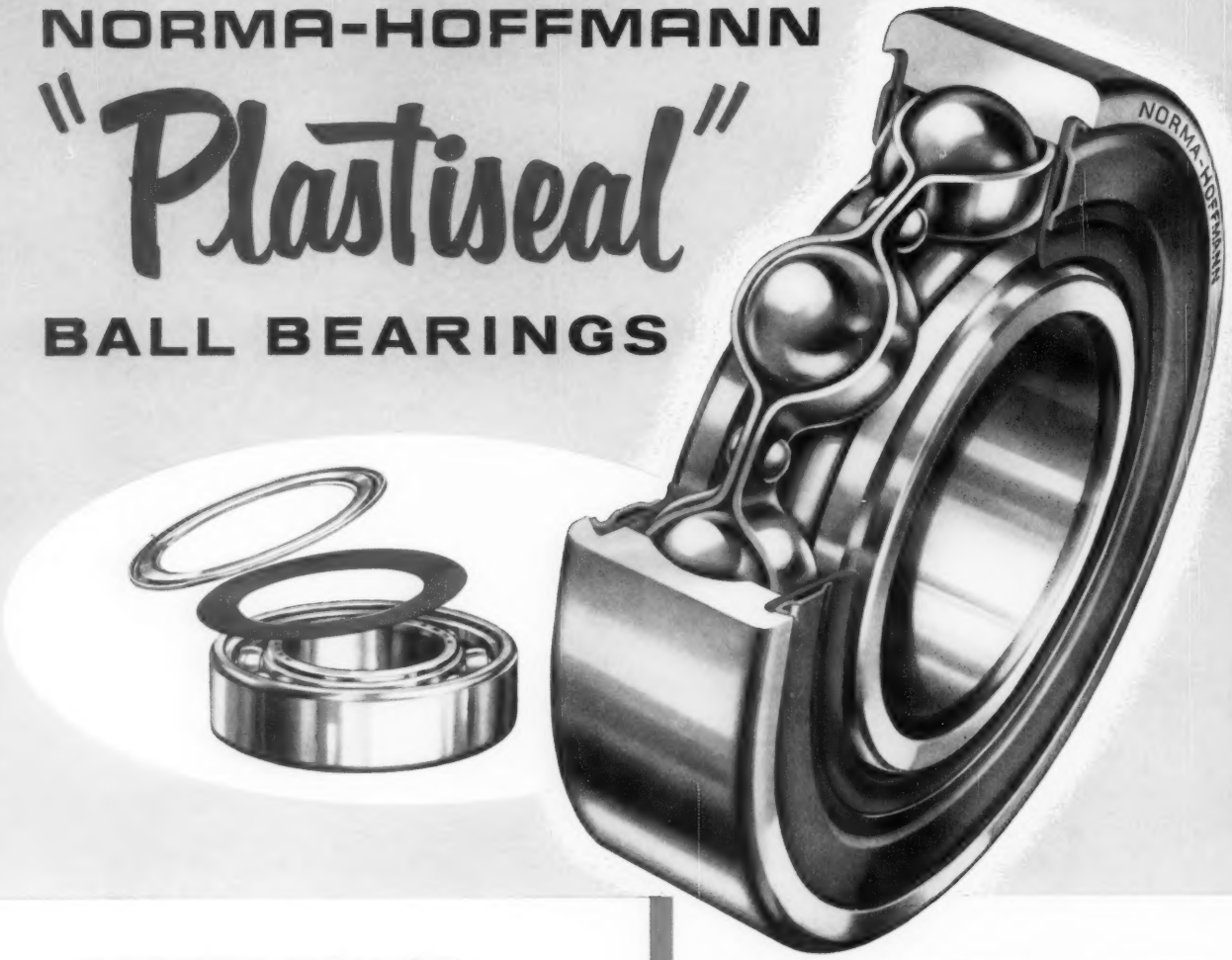
A PENTON PUBLICATION — BIWEEKLY

Static Controls

Contents, Page 3

FARNSWORTH

NORMA-HOFFMANN "Plastiseal" BALL BEARINGS



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Norma-Hoffmann *"Plastiseal"* Ball Bearings keep out damaging dirt and retain full lubrication. That's because they're made with oil and grease resistant synthetic rubber seals, firmly attached to the outer ring, with very light rubbing contact on the inner ring's smooth recess.

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- Compact design for completely sealed bearings.
- Prepacking with metered quantity of wide temperature range grease.

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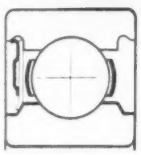
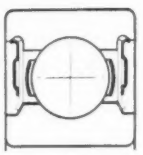
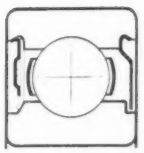


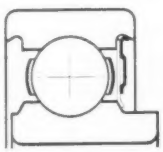
"K" Series
with Single Rubber Seal



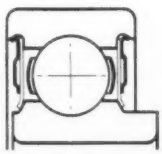
"KK" Series
with Double Rubber Seal



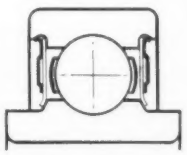
"KP" Series
with Single Rubber Seal and Metal Shield



"8000-K" Series
with Single Seal and Extended Inner Ring



"8000-KK" Series
with Double Seal and Extended Inner Ring



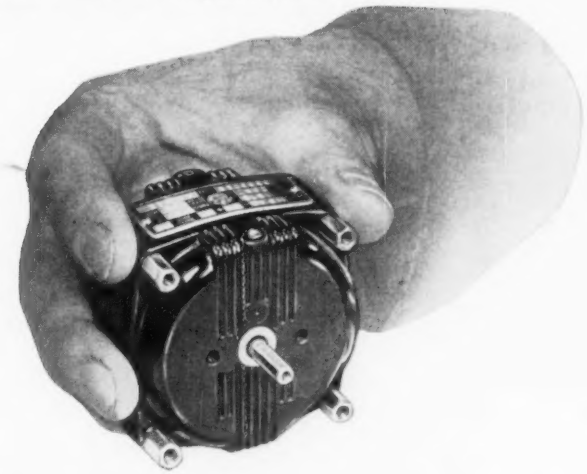
"88000-KK" Series
with Double Seal and wide Inner Ring

Circle 401 on Page 19

precision ball, roller & thrust bearings

NORMA-HOFFMANN
BEARINGS CORPORATION • STAMFORD, CONN.
founded 1911

for instruments, timing devices,
control apparatus and similar applications



USE BODINE K-2 MOTORS

...they're small, only 2⅜" high
instantly reversible
totally enclosed
1/2000 to 1/500 horsepower

This Bodine Type K-2, ball bearing motor is among the smallest distributed-wound motors manufactured today. It's ideal for those "hard-to-get-at and out-of-the-way" installations because of its small size and extreme dependability. It delivers considerably more power than "clock-type" motors, and it's particularly well-suited for powering instruments, timers, controls . . . and similar equipment requiring relatively low output, and steady, trouble-free service.

Bodine K-2 motors are available synchronous or nonsynchronous . . . and with or without speed reducers. Speed reducer models have high starting torque of not less than 150% of full load torque at room temperature.

Write for bulletin 1024A,
"Bodine Type K-2 Motors"... bulletin 1023B,
"Bodine Parallel Shaft Speed Reducer Motors"

BODINE ELECTRIC CO., 2508 W. BRADLEY PLACE, CHICAGO 18

BODINE
fractional / horsepower
MOTORS

BODINE

...the power behind the leading products

The Bodine line includes 265 different stock types and sizes ready for fast shipment.

...third of a series

How to make motors last longer

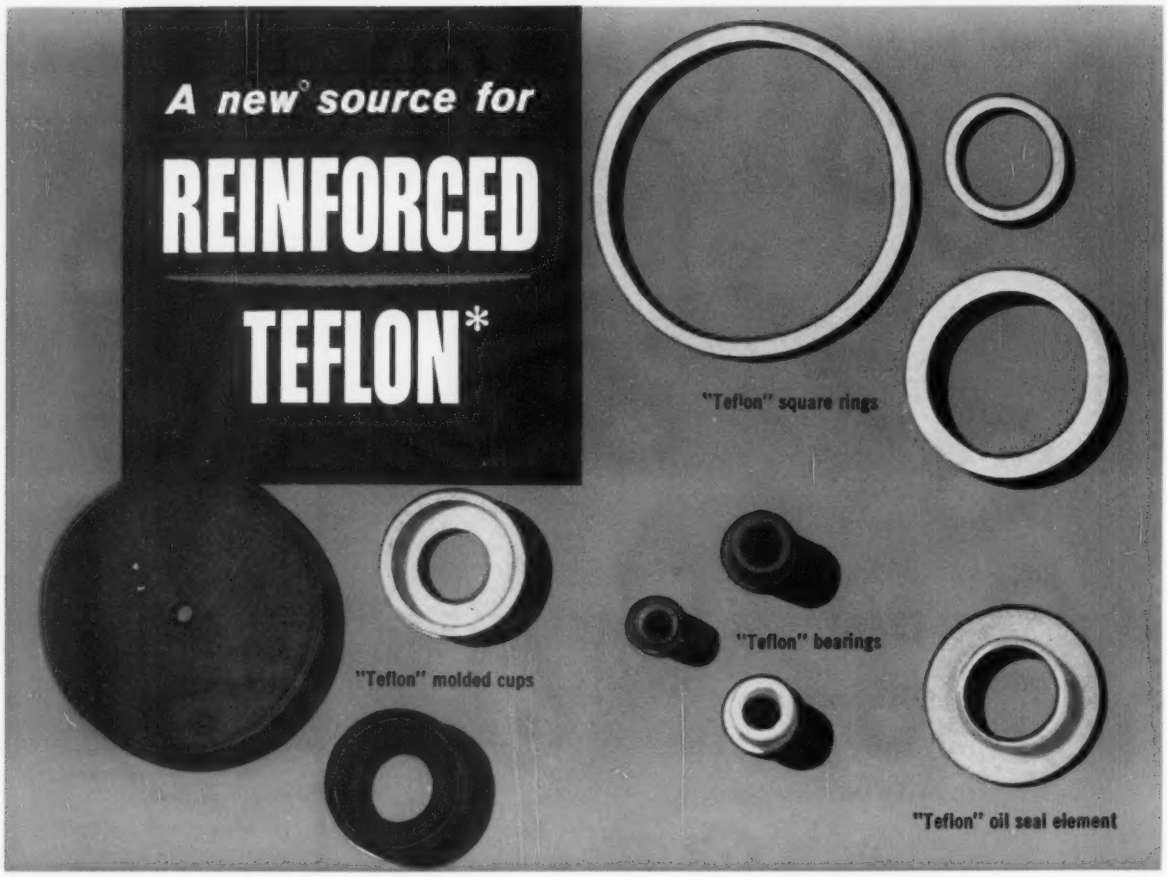
Careful maintenance is the best and least expensive way of getting dependable service and long life from your fractional horsepower electric motors. Here are maintenance suggestions:

Be sure loads do not lock on reducer motors. Provide a friction clutch if there is any possibility that the driven shaft may be locked. Such locking will quickly build up a tremendous force within the reducer gears . . . causing them to strip or break. If you must use a flywheel, attach it to an extended *high-speed* motor shaft, not a *low speed* shaft. If a flywheel is attached to a low-speed shaft, it tends to keep this shaft turning after the motor has stopped . . . with the same effect as locking the driven shaft.

Be sure your motor is properly rated for its job. If it is necessary to move your motor from one job to another . . . or to operate it continuously where previously you have been running it for short periods of time, be sure it is rated properly. For example, one type of motor is rated for intermittent duty because the temperature rise within the motor will not be excessive. If you put this same motor on a continuous duty application, there will be an excessive temperature rise which will burn out the motor . . . or at least deteriorate the insulation.

Free copies of article on temperature rise measurements available

Three of the fundamental methods for temperature rise determinations set up by the American Institute of Electrical Engineers are discussed in the latest issue of "The Motorgram," a bimonthly publication. Copies are available on request.



C/R now offers you the advantages of reinforced TFE... designed, compounded and molded by a single source!

If your work involves sealing applications, you are probably familiar with "Teflon", Tetrafluoroethylene Resin. The extreme versatility of its chemical, thermal and mechanical properties are unmatched by any other material on the market.

You may not be, however, fully aware of the degree to which these properties can be distinctly improved by the use of reinforcing inorganic additives. For example, "Teflon" can be blended with inorganics to increase:

- **Resistance to deformation under load — by a factor of 10**
- **Resistance to wear by rotating shafts — by as much as 500 times**
- **Stiffness — by a factor of 4-5**
- **Thermal conductivity — by a factor of 5-10**
- **Compressive strength — by a factor of 3-4**
- **Hardness — by 10%**

It is also useful to know that Chicago Rawhide is one of the few fabricators which blends its own "Teflon" compounds, assuring constant quality in batch after batch and permitting compound formulations to be developed rapidly and accurately. Our new laboratory and production facilities are unexcelled – and these facilities are matched by our experience in molding synthetic parts to meet the most critical specifications.

C/R Sirvene welcomes the opportunity to cooperate with you in the design and production of "Teflon" and reinforced "Teflon" packings, bearings, gaskets, rings, or other parts.

If you are interested in "Teflon" write for your free copy of Sirvene Materials Bulletin CT-1.

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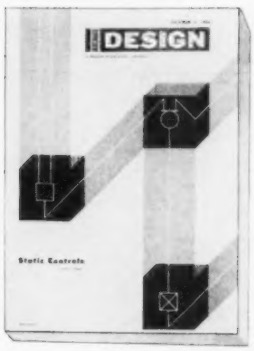

Front Cover: AND, OR, and NOT logic elements are combined by artist George Farnsworth to highlight Ed Rudisill's article on static controls, Page 120.

October 2, 1958

Hydrofoils 22

NEWS REPORT—How underwater wings increase the speed and performance of boats.

The Ideal Creative Supervisor 28

EUGENE RAUDSEPP—*Part 2:* What the head of a creative group must do to inspire, encourage, and instill confidence in his staff.

Programing for Complex Projects 98

R. G. MURDICK and A. B. OPPENHEIM—Principles and practices of programing: What it is, how to set it up, and how to use it for large-scale engineering projects.

Precision Gear Trains 106

RAYMOND H. WADSWORTH—*Part 1:* A study of the inherent causes of lost motion.

Low-Pressure Molding 113

JAMES C. ROLLER—Design and production considerations of an economical process for producing reinforced plastic parts.

Static Control 120

E. L. RUDISILL—Methods of applying magnetic logic elements and amplifiers to perform "switching" operations in machine-control systems.

Filtering Hydraulic Circuits 128

JAROSLAV J. TABOREK—*Part 2:* A summary of filtration methods with an evaluation of various types of filters in terms of operation, application, cost, and effectiveness.

Cones and Circular Segments 135

A. M. WOODALL—*Data Sheet*—Calculation procedures for laying out circular segments on plates or strip for economical use of material.

CONTINUED NEXT PAGE

THE PROFESSIONAL JOURNAL FOR ENGINEERS & DESIGNERS

MACHINE DESIGN

October 2, 1958

Volume 30—No. 20

" . . . things proper to man." 97

COLIN CARMICHAEL—*Editorial*

Engineering News 6

Ceramic honeycomb has unique properties—1958 research budgets show increase despite recession—aircraft builders find using titanium and magnesium pays off—Navy studies Polaris for toxic materials—10,000-amp pump circulates liquid sodium—missile business poses exacting demands—running gears in inert gas doubles load capacity.

Scanning the Field for Ideas 104

Two-speed motion—programed contact closing—3-D spiral expander.

Design in Action 117

Variable-pitch plastic helix spaces jars in packing machine—proportioning bars control output ratio of cylinders.

Tips and Techniques

Developing scroll 112
Graphical integration .. 112
Pen storage 112
Critical roll speed .. 116
Drawing arcs 134
Drawing-board print .. 134

Design Abstracts 139

New Parts and Materials 154

Engineering Department Equipment 180

The Engineer's Library 184

Noteworthy Patents 186

Meetings and Expositions 39

Helpful Literature 142

Subject Index 17
Reader Service Cards .. 19
Advertising Index 197
Business Staff 197

IN THE NEXT ISSUE: 1959 automobiles . . . drafting manual . . . vibration isolation . . . industrial fasteners . . . helical gears.

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Circle 406 on Page 19

Human-Survival Factors Control Missile Design

Navy Studies Polaris For Toxic Materials

NEW LONDON, CONN.—Protection of the crew from toxic effects under prolonged submerged cruise conditions is a factor directly affecting design of the Navy's Polaris missile, according to Dr. Joseph W. Wissel, a senior engineering psychologist on the Polaris program at Lockheed's Sunnyvale, Calif., plant.

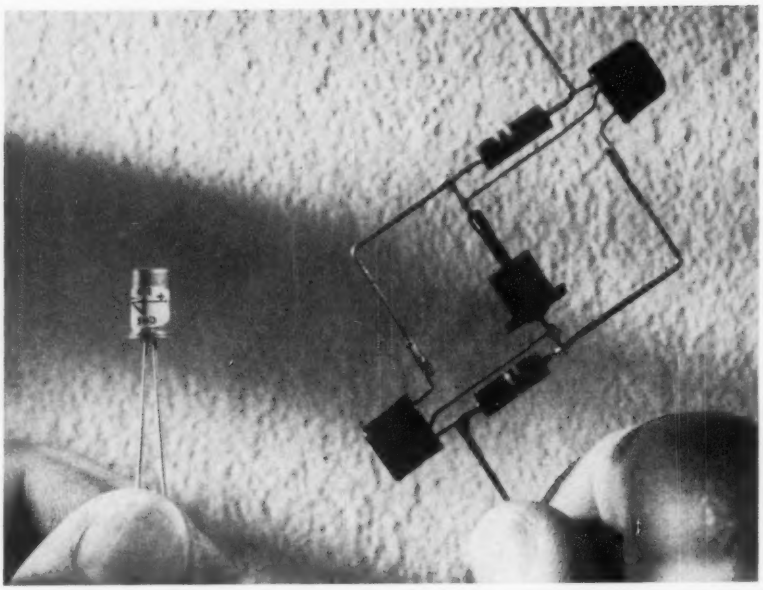
Speaking here before a recent submarine and space-medicine symposium, the scientist noted that minor human-factors difficulties in experimental aircraft have occasionally delayed development programs by perhaps a month or two. He predicted that similar human-performance limitations could delay more advanced vehicle programs by a year or longer.

For example, if research indicates that a certain substance might cause toxic fumes in the carrying submarine's atmosphere in event of an electrical fire or exposure to sea water, an all-out effort must be made to substitute another material.

The Navy's Special Projects Office has set up a medical advisory committee, with representatives from the Bureau of Medicine and Surgery, the Medical Research laboratory, and other Naval Agencies. Its first action was to set up a system for studying the toxicity of items which were probably going to be used in the design of the Polaris missile, Dr. Wissel said. This system has five main steps:

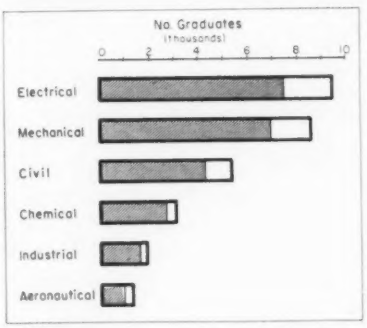
- Lockheed inventories all materials and components which are to be used—or which may be used in the future.
- Materials are screened for potential toxicity, using ground rules of the Special Projects Office.
- A list of items which are not eliminated is passed on to the Special Projects Office.
- Special Projects, using the resources of the Navy Medical laboratories, conducts a more intensive screening which may require an extensive toxicological research program.
- The toxic potential of identified materials and components is relayed to Lockheed and, whenever possible, a nontoxic substitute is incorporated in the design. If it is not possible to use a substitute, special safeguards for personnel are built into the missile design.

Beyond doubt, Dr. Wessel points out, the limiting factor in the development of the advanced submarine or space vehicles of the future is the man—not only his ability to perform duties necessary to operation of the vehicle, but his ability to survive in the hostile environment he will encounter under the sea and in outer space.



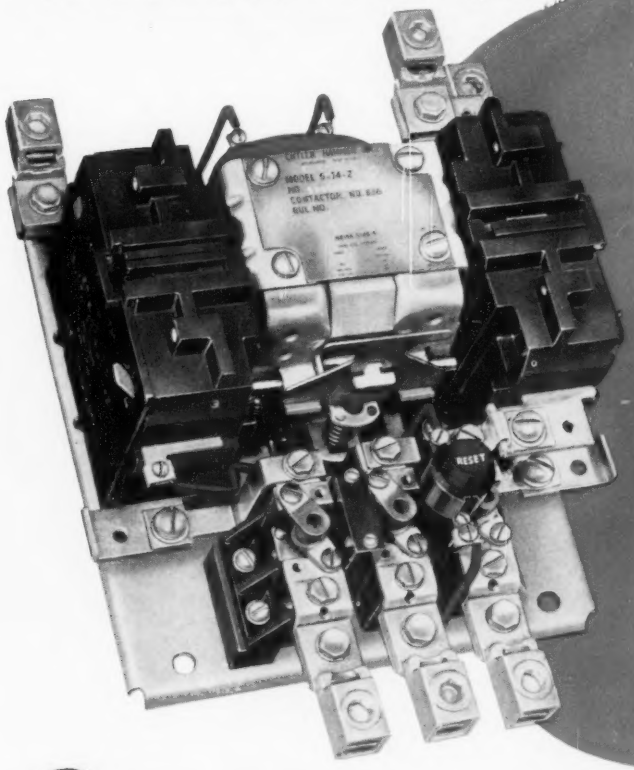
ONE EQUALS FIVE. Transistor diode is equivalent to a combination of five separate elements. It is switched from an open circuit (high-impedance state) to a closed circuit (low-impedance state) by control of voltage and current. The device, a 4-layer transistor diode, has many applications as a result of its unique electrical properties, tiny size, and ability to replace a number of components. It is produced by the Shockley Transistor Corp., subsidiary of Beckman Instruments Inc.

New Engineers—Forecast for '59



NUMBER OF GRADUATES to receive bachelor's degrees in various branches of engineering in 1959 is predicted in the above chart. For comparison, shaded portions of the bars represent actual figures for 1957. Estimates are supplied by Engineers Joint Council, which polled colleges with curricula accredited by the Engineers Council for Professional Development.

50 Hp 220 Volts, 100 Hp 440/550 Volts Max. Polyphase



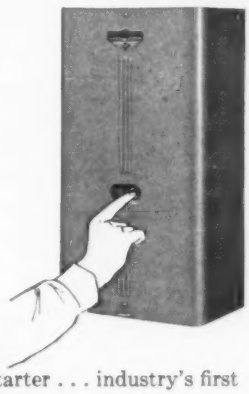
New SIZE 4 STARTER

. . . another Cutler-Hammer Three-Star achievement

New *compact design saves valuable panel area*

New *parallel contact design provides increased electrical life at full capacity*

New *low mass movable members insure superior mechanical life*



This is the new Cutler-Hammer NEMA Size 4 Starter . . . industry's first large horsepower starter offering all the desired features of the famous Cutler-Hammer Three-Star Motor Control line. Smaller, more compact, this new starter simplifies control panel design and saves valuable panel area. Tests of the new parallel contact structure show vastly improved electrical life even when operated at full capacity. Further, this new design reduces the size and weight of the movable members resulting in less impact wear and unsurpassed mechanical life. We've tested it against all others, why don't you? The new Cutler-Hammer Size 4 Starter ☆ installs easier, ☆ works better, ☆ and lasts far longer. Get all the facts today. Write for the new descriptive bulletin EN 125-V243, Cutler-Hammer Inc., Milwaukee 1, Wisconsin.

Look for these outstanding features . . . you'll find them only in Cutler-Hammer Three-Star Motor Control

- U-shaped cover easily removable for unobstructed inspection and accessibility
- Straight through wiring . . . line terminals at the top, load terminals at the bottom
- New pressure type terminals cut wiring time and effort
- Adjustable overload relays can be set to trip within 3% of full load motor current
- Precision cast overload sensing coils can't lose their accuracy
- Widely desired three-phase, three-coil overload protection is a standard optional feature . . . no special attachments or enclosures
- Indestructible molded magnet coil . . . color coded for positive voltage and frequency identification
- Easily installed convertible electrical interlocks require no special adapters . . . provide up to four extra control circuits
- Available as non-reversing, reversing, and multi-speed contactors and starters in the open type, NEMA 1, and all special purpose enclosures.

CUTLER-HAMMER CONTROL C-H

CUTLER-HAMMER

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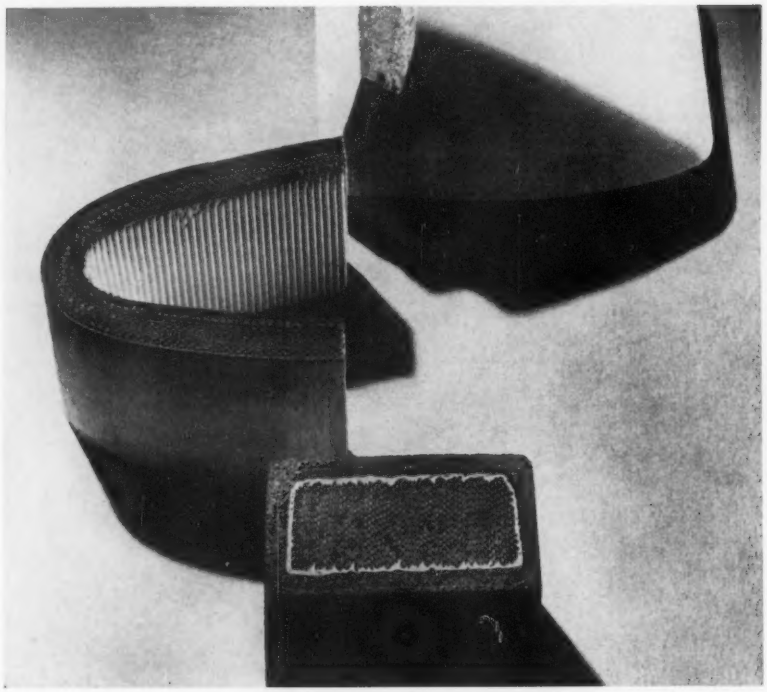
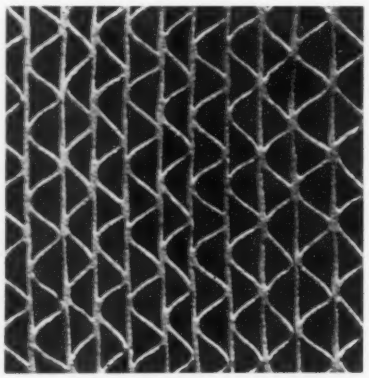
Associates: Canadian Cutler-Hammer, Ltd.; Cutler-Hammer Mexicana, S. A.; Intercontinental Electronics Corporation, Inc.

Circle 407 on Page 19



CERAMIC HONEYCOMB, called Cercor, is a high-temperature, lightweight structure which can be formed in a variety of shapes. Shown are (top) a wedge-shaped piece, cut open to show cellular construction and ceramic rim; (middle) a U-shaped corrugated cellular structure; (bottom) simple Cercor shape with strong ceramic rim which protects thin-edged walls against external pressures. Manufacturer of the new material is Corning Glass Works. Some of its physical characteristics are:

Bulk specific gravity	0.5
Specific gravity of material	2.6
Melting temperature	1250-1350 C
Specific heat (25 C)	0.20 cal/gm
Linear coef. of thermal expan.	1×10^{-7}/C
Short-term max. temp. (no load)	1000 C
Long-term max. temp. (no load)	700 C
Surface area	1500 sq ft/cu ft



CERAMIC CELLULAR SECTION, shown here greatly magnified, has 20 corrugations per in. Some uses of Cercor are in gaseous heat exchangers, as a high-temperature structural material, and in air preheaters and aftercoolers.

Gear Load Ratings Doubled by Inert Gas Atmosphere

SAN ANTONIO, TEXAS — Running high-speed gears in a lubricant bath exposed to nitrogen or argon instead of atmospheric air can boost gear load-carrying capacities by factors up to 2.0. This is the finding of Southwest Research Institute scientists working on an Air Force sponsored study of the lubrication requirements of missiles

Increased load-carrying capacity for gear trains is especially important in aircraft and missiles because gear weight must be kept at a minimum. This means that gears must operate at extreme loads, speeds, and temperatures. Removal of the oxygen in atmospheric air, or saturation of the lubrication space with an inert gas such as nitrogen, offers

Topics

Californium: Here it comes. Physicists at the University of California have built up 0.06 micrograms of this man-made element. The microsynthesis took six years. Californium was discovered after the first atomic tests at Eniwetok in 1950 in "comparatively" small amounts (a few atoms).

• • •

"Music" for the ears of the blind may soon enable them to read regular books and magazines. A little nine-pound machine, developed at Battelle Memorial Institute, translates letters into musical tones when the person using the device moves a probe across a printed line. Two lights and a lens project an image of the letters on a row of photoelectric cells. Each photocell reacts to the black in the letter by actuating an oscillator to generate a specific pitch. The various pitches are translated to musical tones by earphones. Trained users of the device are expected to be able to read 15 to 30 words a minute.

• • •

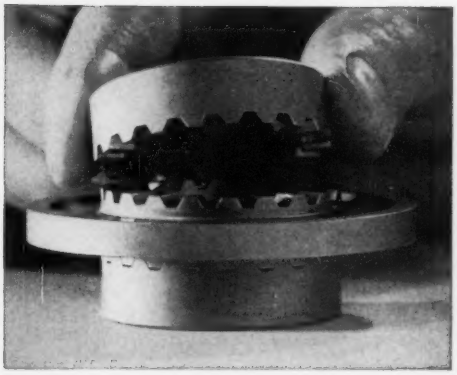
More people are keeping cool, with air conditioners, according to a meteorologist with the U. S. Weather Bureau's Office of Climatology. Number of central installations of air-conditioning equipment in commercial buildings is expected to climb to two billion next year. In 1953, only 600 million were in use. Comparison of this figure with the projection for 1959 shows that the rate of increase will average 233 million a year.

• • •

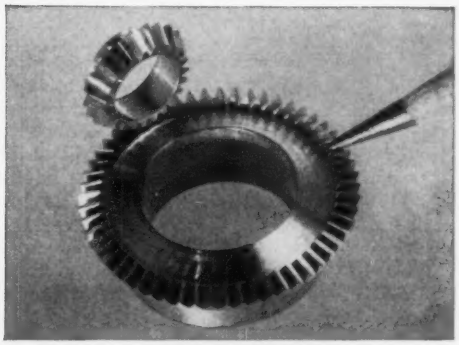
Pocket-size radiation detector was developed to protect ground personnel working on airborne radar. The size of a cigarette package, the instrument transmits a warning sound through an earphone. Heart of the detector is a small battery-powered neon light. Exposure to a radar beam increases its brightness, and resulting voltage variations register as sound on the detector. Intensity of sound is related to proximity of the radar transmitter. Developed by a Douglas Aircraft Co. electronics test designer, the detector is made by Erickson Products Co., San Francisco.

• • •

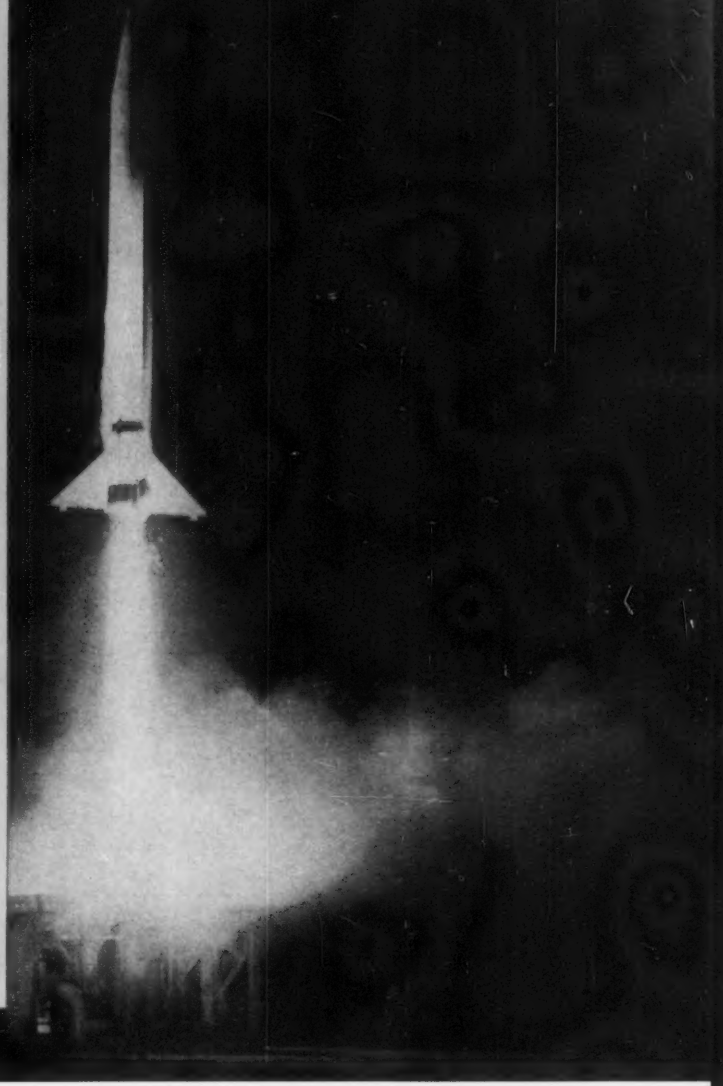
Soft-tire indicator, about the size of an ordinary valve cap, shows at a glance if tire pressure is correct. The British-made Indicap pops out a small red plunger when the valve cap it is built into is applied to a properly inflated tire. If pressure falls 3 lb or more, the plunger drops in. The device is made for a variety of pressures.



CURVIC COUPLINGS provide an accurate, light, compact, and self-contained connection in which the teeth both center and drive. The Curvic design represents a new standard in the application of coupled parts.



BEVEL GEARS



When a gear or a coupling determines the *accuracy of trajectory* . . .

When a missile or rocket works on paper the best way to get it into the air is to see to it that all the parts agree with the paper work.

And when one of those parts is a bevel gear or coupling, Gleason engineers can help you three ways:

1. Engineering service. Our full staff of engineers is ready at all times to help you develop bevel gear combinations and Curvic® Coupling designs. They can help you make sure that either part meets your specifications.

2. Machines to cut or grind to your tolerances. You can produce any fine pitch gear—spiral bevel, hypoid, Zerol® or Coniflex®—precisely and economically with any of five Gleason machines.

No matter how rigid your specifications or the size of your parts, our engineers can help you select the right machine or combination of machines for 100% accuracy.

3. Complete testing equipment. We have engineered a series of testers for making certain that all parts do meet your critical specifications. For example, on the Gleason No. 104 Hypoid Tester you obtain a permanent test record to help you match pairs properly and to keep a graphic record of the rolling qualities, tooth spacing, and concentricity of your parts.

Any or all of these services are yours for the asking at any time.

GLEASON WORKS

Builders of bevel gear machinery for over 90 years

1000 UNIVERSITY AVE., ROCHESTER 3, N. Y.

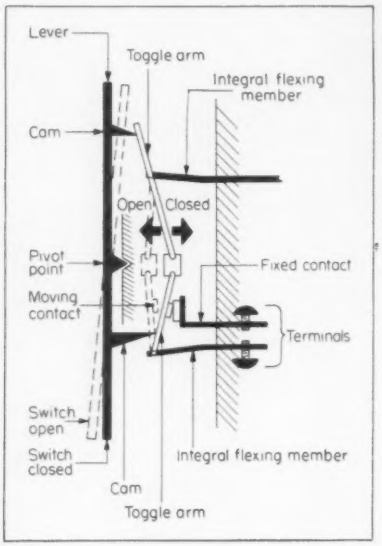
71

Circle 408 on Page 19

attractive possibilities for raising gear-train capacities.

Although results obtained so far have been obtained only with mineral-oil based lubricants, work is in progress to study the effects of air starvation on synthetic lubricants.

It has been found that straight mineral oils, as well as mineral oils fortified with three different extreme-pressure additives, all exhibit decided increases in load-carrying capacity. The three additives were a phosphorous type, a sulphur type, and a chlorine type.



FLAT-PLATE wall switch is revolutionary in design. Light touch at top of plate turns switch "on;" touch at bottom turns switch "off." Internal mechanism of switch, made by Bryant Electric Co. of Bridgeport, Conn., has the form of a toggle joint operated as an overcenter linkage. Force is applied to the toggle arms instead of to the center pivot.

FINS ARE COOL not only in car styling, but as functional additions to car radiators. An aluminum-finned, brass-tubed radiator developed by ALCOA costs and weighs 20 per cent less than conventional copper-brass assemblies. It has proved highly successful during a 5-year test program and is said to require only minor changes in radiator manufacturing procedures.

Fifth Conference on Mechanisms: October 13-14

Design and application of mechanisms will be the theme of the impressive two-day meeting cosponsored by Purdue University's School of Mechanical Engineering and MACHINE DESIGN. Here are the details:

Time: Monday and Tuesday, October 13 and 14.

Place: Purdue University, West Lafayette, Ind.

Technical sessions: Leading authorities in mechanisms design will present 19 papers during two days of discussions. The complete program, with abstracts of all papers, appeared in the September 4 issue of MACHINE DESIGN, Page 30.

Social events: Conference banquet on Monday evening, Luncheon on Tuesday. Banquet speaker is Dr. Richard W. Wallen, prominent psychologist, management consultant, and an expert on the personal and professional sides of engineering. Luncheon speaker is James F. Young, manager of General Electric's General Engineering Laboratory, Schenectady, N. Y. Mr. Young is an expert on engineers and engineering. Both speakers will deal with "An Engineer's Future," covering personal and environmental factors that contribute to an engineer's success, and the opportunities and the requirements that face the engineer in an age of expanding technology.

Registration: Page 199 of this issue gives complete details. For any questions, write to Editor, MACHINE DESIGN, Penton Bldg., Cleveland 13, Ohio.

Discomfort index won't make you any cooler on a hot, humid day, but it will help determine the design of air conditioners in various parts of the nation and will assist power companies in determining energy demands for air conditioners on any given day. Earl C. Thom, meteorologist with the office of climatology, U. S. Weather Bureau, stated at the University of Michigan recently that there long has been a need for a simple, quick, generally accepted way to tell how uncomfortable a hot day really is.

Thom explained that the discomfort index can be determined by adding the dry bulb temperature (the reading on an ordinary Fahrenheit thermometer) to the wet bulb temperature, which can be derived by putting a bit of muslin around the bulb of a thermometer, wetting it, and then whirling the thermometer around. The second reading will be lower because of the cooling influence of evaporation. Multiply the sum of the two temperatures by 0.4 and add 15. The result is the discomfort index.

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GEAR STEEL

Gears are a special steel problem. Controlled grain size, freedom from porosity, segregation, and non-metallic inclusions are essential. Chemistry is critical.

For these reasons, gear manufacturers insist upon electric furnace steels. Aristoloy, produced by the electric furnace method under stringent controls, from raw materials to melting, meets these requirements.

Aristoloy billets and bars in a wide range of A.I.S.I. analyses are available in carburizing and through-hardening grades. For assistance in selecting the best material for your job, call or write. A Copperweld Field Metallurgist will be glad to work with you.

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Circle 409 on Page 19

Research Gets a Raise Despite Business Drop

Budgets Are Up 4% Over 1958 Spending

NEW YORK—Research and development activities received a vote of confidence this year in the form of a larger slice of industry's budget than in 1957. A survey of over 800 companies by the American Management Association shows a 4 per cent average increase over 1957 in money allocated for research. Last year, research dollars averaged 2.8 per cent of sales.

Budget increases are indicated for 18 of the 24 industries surveyed; decreases, for six. Among the big spenders for research are the transportation-equipment industry (exclusive of automobiles and airplanes) with a budget increase of 26 per cent; service machinery, 13.3 per cent; and chemicals, 10 per cent. Greatest reductions were for engines and turbines (9 per cent) and autos (6 per cent).

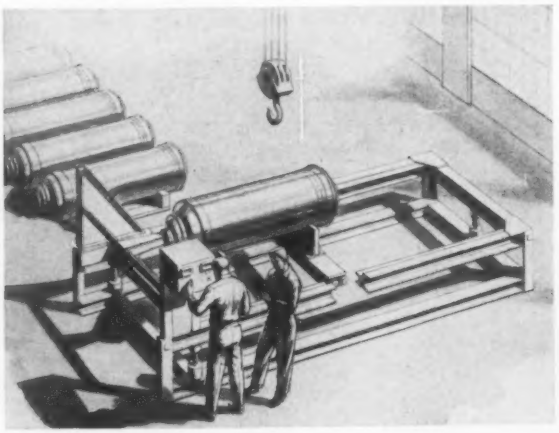
Dr. Philip R. Marvin, manager of AMA's Research and Development Div., interprets results of the study as indicating:

- Budgets are, in most cases, tied to near-term income expectations.
- Attempts are being made to offset cutbacks by selecting research projects more carefully and through operating economies.
- Emphasis is on development of items that are "close to the shipping-room door."

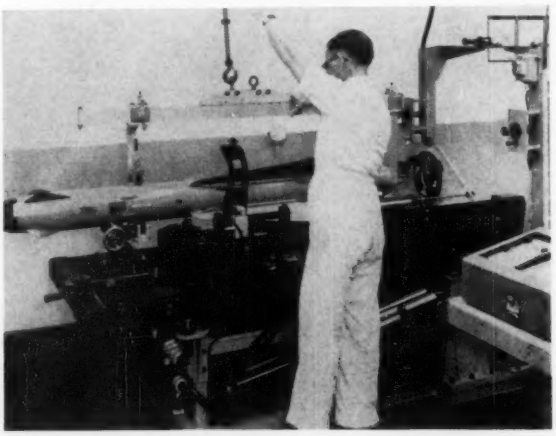
Research-Budget Changes: 1957-1958

Industry Group	Number of Companies Reporting	Budget Changes (1957-1958) Up	Same	Down	Avg Change (Per cent of 1957 Budget)
Agricultural Machinery	5	2	3	0	3.4
Aircraft	20	7	8	5	3.8
Autos	7	3	2	2	−6.0
Chemicals	209	131	67	11	10.0
Construction Machinery	9	2	5	2	−15.0
Electrical Machinery	62	23	20	19	4.0
Engines and Turbines	15	4	1	10	−9.0
Fabricated Metal Products	68	23	21	24	0.5
Food and Beverages	69	41	21	7	8.3
General Industrial Machinery	33	12	12	9	2.2
Instruments	73	24	34	15	1.0
Metalworking Machinery	5	2	1	2	2.2
Miscellaneous Machinery and Parts	22	5	10	7	−3.1
Miscellaneous Manufacturing	58	15	24	19	−2.0
Nonferrous Metals	19	7	6	6	0.2
Office Machinery	18	10	3	5	5.2
Paper	30	16	8	6	5.0
Petroleum Refining	18	8	8	2	2.4
Rubber	16	7	3	6	−2.6
Service Machinery	4	4	0	0	13.3
Steel	16	7	6	3	4.0
Stone, Clay, and Glass	41	30	6	5	7.1
Textiles	2	1	1	0	2.5
Transportation Equipment (other than autos and aircraft)	14	6	5	3	26.0

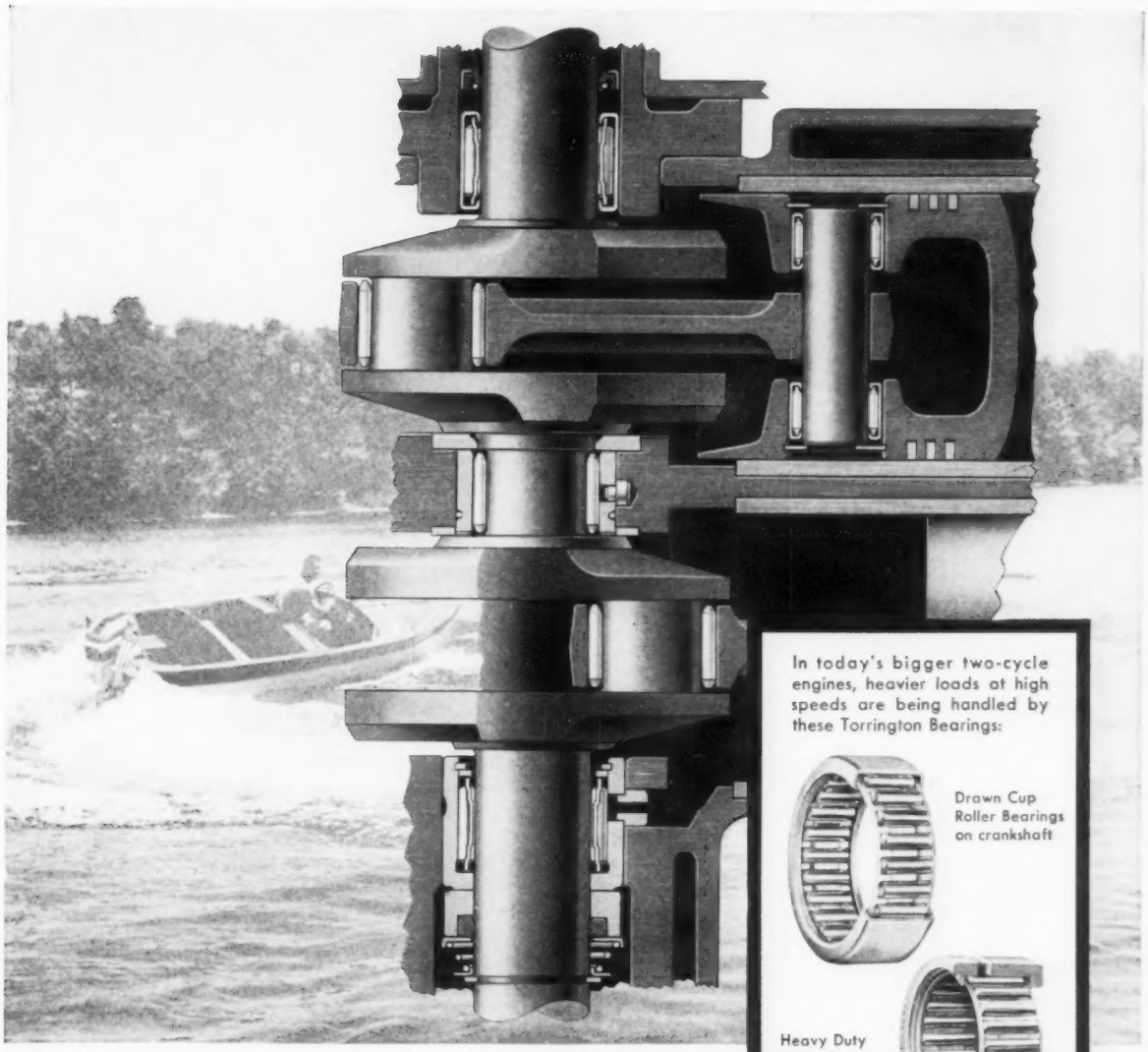
Balance of Power . . . Automatically



CG FOR A SOLID-FUEL ROCKET ENGINE is found to an accuracy of ± 0.1 per cent by this machine developed by Hunter-Bristol Div., Thiokol Chemical Corp. Model shown handles engines weighing from 200 to 15,000 lb and measuring up to 60 in. diam and 15 ft long without modifying the setup. Readout of the machine—which also measures engine weight to 0.1 per cent—is digital. Force transducers providing the output signals are strain-gage load cells which need no correction for a 60-100 F temperature range.

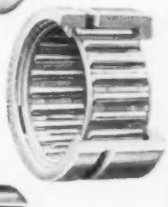


CG FOR THE SUPERSONIC FALCON—both fore and aft and laterally—is pinpointed automatically and accurately by a weight-and-balance machine at Hughes Aircraft, Tucson, Ariz. Besides reading out cg position, the instrument finds total weight and thrust-axis alignment for Air Force's air-to-air missiles as they leave the production line. Spotting a missile on the weighing bed and recording its characteristics takes about 5 min. System was designed and built by Electronics and Instrumentation Div., Baldwin-Lima-Hamilton Corp.

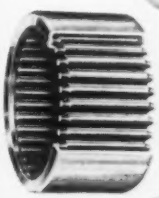


In today's bigger two-cycle engines, heavier loads at high speeds are being handled by these Torrington Bearings:

Drawn Cup Roller Bearings on crankshaft



Heavy Duty Roller Bearings



Full Complement Needle Bearings on wrist pins

Needle Rollers with crankpin ends

Fractured outer race for center main on crankshaft

What's new in two-cycle engines?

Today's improved performance and increased power made possible by recent developments in Torrington Bearings!

In this schematic drawing of a typical two-cycle engine, a Torrington Drawn Cup Roller Bearing and a special Torrington Heavy Duty Roller Bearing provide several improvements in the crankshaft mounting. Shaft-riding retainers guide the rollers at the pitch line and provide ample lubricant circulation. Positive roller guidance insures correct bearing performance despite shaft deflection. Split center bearing on crankshaft features a fractured outer race for positive location of the race halves.

Full complement Torrington Needle Bearings and Needle Roller assemblies with crankpin ends complete the compact, high-capacity design to insure long, trouble-free service life. To secure the advantages of modern Needle Bearing design in your application, consult Torrington's engineering department. **The Torrington Company, Torrington, Conn.—and South Bend 21, Ind.**

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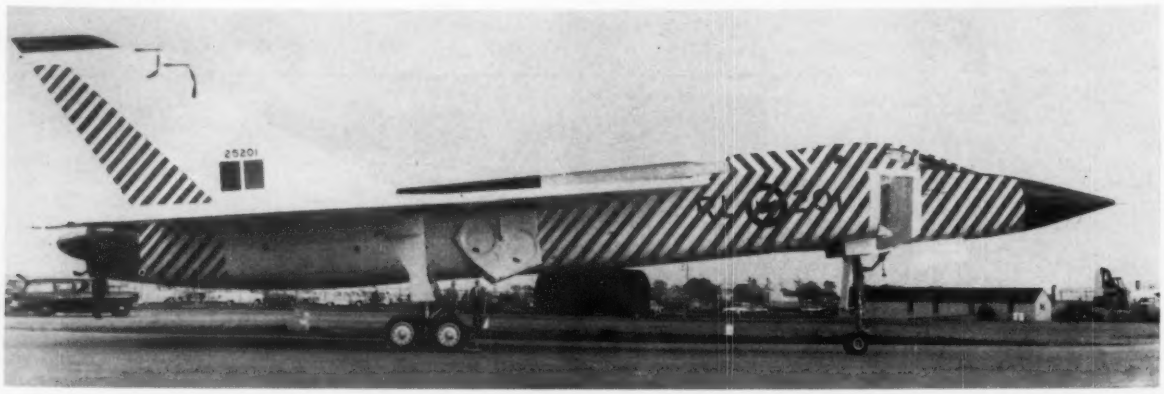
Circle 410 on Page 19



Stripes show lightweight magnesium skin areas on the Avro Arrow, Canada's new 1000-mph interceptor.

Pioneering with Magnesium and Titanium Pays Off Big for Aircraft Builders

LAVISH USE of titanium and magnesium in aircraft engines and airframes is largely responsible for the unprecedented power-to-weight ratios of today's jet fighters and bombers.

Chance Vought Aircraft Corp. and Dow Chemical Corp. recently disclosed how these metals are used to advantage in construction of two of the world's fastest military aircraft.

Titanium and Crusader III

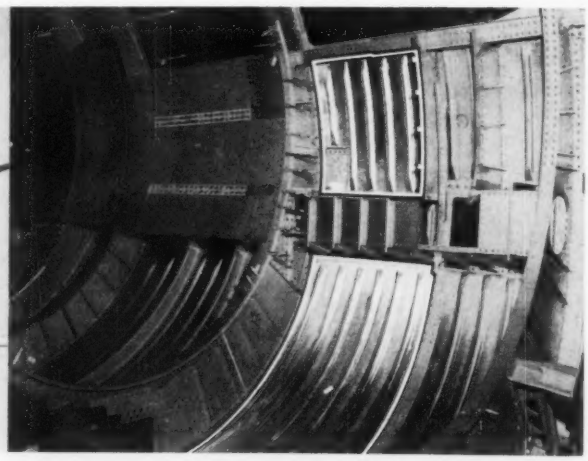
Chance Vought pioneered in developing spotwelding techniques for titanium in 1953. The F8U-1, first of the Crusaders, had titanium skins, frames, and bulkheads in the aft fuselage section.

Working from this background, Chance Vought further refined titanium design and fabrication techniques when building the bigger aft section for the new Mach-2 Crusader III. Rather than adding more frames, stiffeners, and angles, Chance Vought designed a composite panel made up of beaded inner skins of pure titanium spotwelded to 8 Mn alloy outer skins. Weight saving is significant: An access panel weighs 2.3 lb per sq ft when built by the old method; only 1.6 lb per sq ft by the new method. In addition to design and manufacturing advantages, a clean assembly for servicing is provided, since many separate pieces and raw edges of sheet metal are eliminated.

As a further improvement, Chance Vought engineers developed a forming technique for titanium that eliminates the separate stress-relieving operation. Final forming and stress relieving are done in one operation through the application of heat and pressure during press forming of the beaded skins. Curved panels as large as 32 x 40 x 6 in. have been formed successfully.

Magnesium and the Avro Arrow

A magnesium skin covers most of Canada's first-line fighter. Machined magnesium - thorium (HK31A) plate is used on the underside of each wing in areas



Composite inner-outer skins on the Chance Vought Crusader III represent a major design and producibility improvement in titanium airframe structures. Significant reduction in number of sheet metal parts leads to fewer fasteners, less fabrication and assembly time, and substantial savings in material and weight.

where built-up fabrication is impractical.

Most of the Arrow's magnesium skins require moderate two or four-directional forming. To accomplish it, Avro shuns conventional hot-forming methods for a novel vacuum-forming technique closely related to metal-to-metal autoclave bonding.

By this process a magnesium blank is taped to a preformed aluminum master skin. The assembly is padded and enclosed in a plastic bag; air within the bag is then exhausted. External pressure holds the magnesium to the aluminum contour. Next the bag and contents are moved into an autoclave, where pressure and heat cure the magnesium contour. The technique is also used successfully for severe one-directional forming, Avro reports.

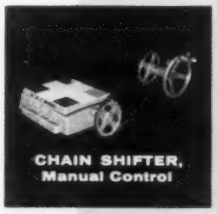
Arrow's Orenda Iroquois powerplant contains several magnesium castings, including some cast from high-temperature alloys. They range in weight from less than 1 lb to more than 100 lb.

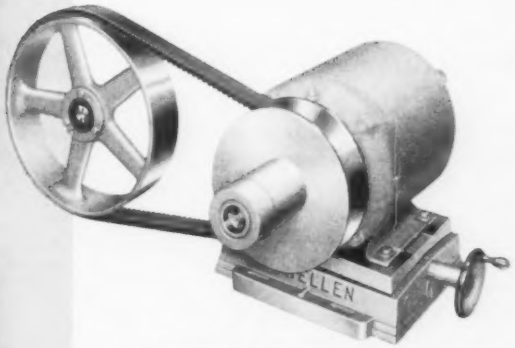
$5000 Award Encourages Flight into Space

NEW YORK — Research projects in the fundamental sciences relating to space travel or space technology are eligible for the Louis W. Hill Space Transportation Award, to be administered annually by the Institute of Aeronautical Sciences. Consideration will be given to research on take-off, navigation, re-entry, environmental conditions, biological and psychological factors, etc.

Established for the encouragement of space transportation for peaceful purposes, the Hill award consists of an engraved certificate and an honorarium of $5000 to an individual or up to $10,000 to a team. It is the largest monetary award for scientific achievement available through any society.

The Hill Family Foundation sponsors the award; the Hills of St. Paul, Minn., have backed developments in all forms of transportation for three generations. The first space flight award, whose recipient will be chosen by a seven-man board, is to be presented at the IAS Honors Night Dinner in 1960.



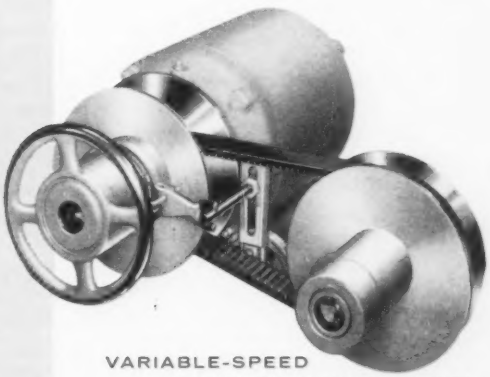


VARIABLE-SPEED PULLEY
Ratings to 15 H.P. Speed Ranges to 4:1

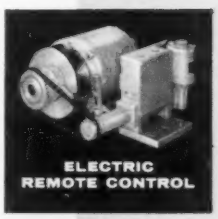
NEW 400 SERIES—VARIABLE SPEED PULLEYS

LEWELLEN

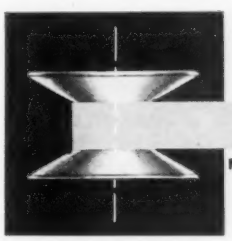
that elusive best speed conveniently available



VARIABLE-SPEED
COMBINATION PULLEYS
Ratings to 25 H.P. Speed Ranges to 10:1



Here are design changes that greatly enhance the flexibility, usefulness and convenience of Variable Pulley Drives. Wherever the drive locates, there is a choice of speed regulating devices that provide precisely adjustable ratios over wide speed ranges. *Check and compare the new Lewellen 400 Series!*



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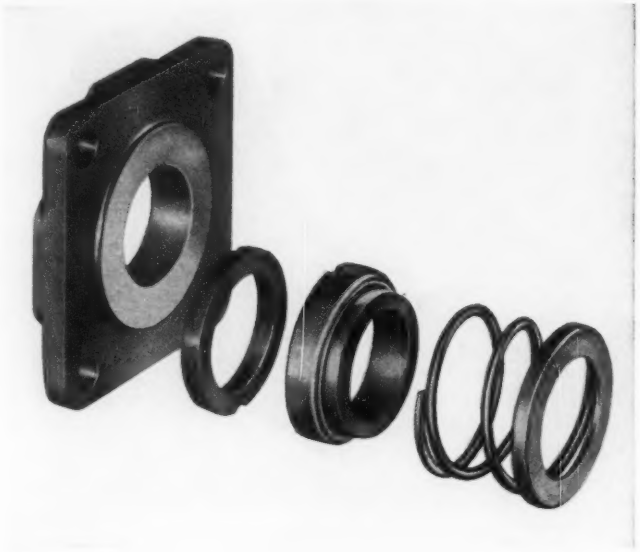
Manufacturing Company, Columbus, Indiana
Distributors in All Industrial Areas. In Canada—
Peerless Engineering Sales, Ltd., Toronto-Montreal

Circle 411 on Page 19

This special-design ROTARY SEAL for a leading car manufacturer's auto air conditioner holds Freon 12 gas tight, functions at 250° F, 250 lbs. PSI, with built-in 100,000 mile life



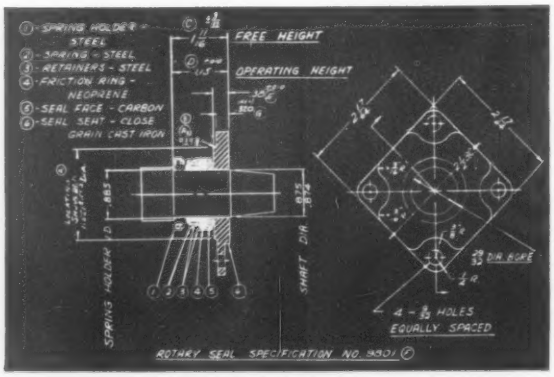
The rapidly growing popularity of air conditioning for passenger automobiles has brought with it considerable problems in developing satisfactory units for this purpose. It early became apparent that existing approaches to sure Shaft Sealing for the compressors used in these units were not going to provide all the answers.

More than three years ago, ROTARY SEAL sat down with the engineers of one of the "Big Three" auto makers, who were in the process of designing new air conditioning equipment for their several makes. It was apparent that no "off the shelf" Seal was going to be satisfactory; the special requirements of installation and use of the units in automobiles were too demanding. Accordingly, ROTARY SEAL took a new look at all the Seal components and set up new standards of performance.

The print shows the latest successful solution in a series of design developments to fit these requirements. And they're tough: to begin with, the Seal must confine Freon 12 gas with no leakage. Special quality control techniques had to be developed to assure critical uniformity, Seal by Seal; for example, the G.E. electronic detector used for continuous checking during production will detect a leak equivalent to 1# of Freon gas in 250 years!

The Seal had to be made to operate properly over the wide range of conditions which might be experienced in passenger car use. Target limits for satisfactory functioning approach compressor shaft speeds up to 5,000 RPM; temperatures up to 250° F; and pressures of 250# PSI. This Seal had to be rugged, too; a basic requirement was a "built-in" life of approximately 100,000 miles, during which satisfactory performance was required.

Thousands of these ROTARY SEALS are now in use, giving unfailing, long-lasting service in passenger autos being driven under all kinds of conditions—on city streets and country roads, by school teachers and salesmen, in Texas, California, Maine. And ROTARY SEAL's continuing engineering research, in concert with the efforts of the car maker's engineers, promise even greater accomplishments for future models.


1 - SPRING HOLDER - STEEL
2 - SPRING - STEEL
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4 - FRICTION RING - NEOPRENE
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6 - SEAL SEAT - CLOSE GRAIN CAST IRON
FREE HEIGHT
OPERATING HEIGHT
SPRING HOLDER
SHAFT DIA
4 - 3/32 HOLES EQUALLY SPACED
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Where There's a Tough Sealing Job, Look For...

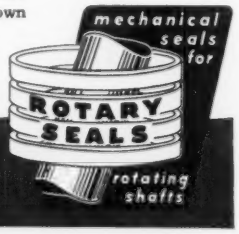
ROTARY SEALS

For more than 20 years—ever since the introduction of the basic ROTARY SEAL principle—we have been specialists in dealing with the *tough* Seal problems. Sometimes only a minor modification of existing models fills the bill; often, as with this auto air conditioning compressor seal, a more elaborate development is required. But in both cases, our concentration on this field and our extremely wide experience has proved invaluable to the makers of famous-name units in such fields as PUMPS—AGRICULTURAL MACHINERY—HYDRAULIC DEVICES—APPLIANCES—GEAR BOXES—COMPRESSORS and many special applications. You'll find ROTARY SEALS a specified element in their production.

Call us in now to sit in with you on *your* Shaft Sealing problems. We have the trained personnel to help get at solutions fastest and best—and the modern production facilities to follow through with finished Seals, to your special specifications, of the highest consistent quality.

WE'D LIKE TO SEND YOU

a copy of our latest fully illustrated, 12-page brochure, "*Solving the Problems of Seals for Rotating Shafts*". We're sure you'll find it helpful in analyzing your own Sealing situation.
Write for your copy today!



ROTARY SEAL DIVISION
MUSKEGON PISTON RING CO.,
SPARTA, MICHIGAN

MACHINE DESIGN

Reader Information Service

SUBJECT INDEX

Editorial and Advertising content classified by subject and listed by page number for convenience when studying specific design problems. For further information on subjects advertised, refer to advertisement and circle Item Number on a Yellow Card—following page.

Accelerometers, Adv. 174
Actuators, Adv. 39, 65, 166
Adhesives, Adv. 46, 79
Alloys, corrosion resistant, Adv. 80
  vacuum melted, Adv. 50
Aluminum and alloys, Adv. 53, 167

Balls, Adv. 34
Batteries, Adv. 169
Bearing materials, Adv. 157, 160, 196
Bearings, ball, Edit. 154; Adv. inside front cover, 13, 21, 44, 55, 67, 153, 171
  cylindrical, Adv. 44, 144
  linear motion, Adv. 149, 175
  miniature, Adv. 153
  needle, Adv. 13, 138
  rod-end, Adv. 178
  roller, Adv. 13, 31, 44, 138, back cover
  sleeve, Adv. 196
  thrust, Adv. 13, 144, 171
Belts, conveyor, Edit. 165
  transmission, Adv. 46, 82
Blowers, Edit. 168; Adv. 185
Books, Edit. 184; Adv. 180, 187, 194
Brakes, Edit. 178; Adv. 75
Brass (see Copper and alloys)
Bronze (see Copper and alloys)
Bushings, ball, Adv. 175

Cameras, high-speed, Adv. 147
Capacitors, Edit. 160
Casters, Edit. 176
Castings, die, Adv. 156, 161, 183
  gray iron, Adv. 150
  light alloy, Adv. 156, 161
  malleable iron, Adv. 87, 150, 179
  sand, Adv. 87
  shell-molded, Adv. 87
Cells, photoconductive, Edit. 168
Chain, conveyor, Adv. 94
  transmission, Adv. 33, 91, 94
Clad metals, Edit. 160
Classified ads, Adv. 170, 196
Clutches, Edit. 178; Adv. 48, 75
Conductors, Edit. 139
Cones and circular segments, Edit. 135
Connectors, electric, Edit. 164, 173
Contacts, Edit. 105
Control systems, electric, Edit. 120
  hydraulic, Edit. 104, 118
Controls, electric, Edit. 105, 120; Adv. 7, 40, 195
  hydraulic, Adv. 39
  mechanical, Edit. 105, 117; Adv. 164, 191, 193
Copper and alloys, Edit. 139
Counters, Edit. 154; Adv. 200
Couplings, fluid, Edit. 175
  shaft, Adv. 168, 174
Cylinders, hydraulic, Edit. 165; Adv. 39, 145, 195
  pneumatic, Adv. 39, 84, 145, 195

Drafting equipment, Edit. 183; Adv. 35, 52, 59, 73, 172, 194, 196

Electric equipment (see specific type)
Engineering department (see Management or Drafting)
Engines, Edit. 38, 140, 166; Adv. 188, 192
Extrusions, Edit. 175; Adv. 5, 189

Fasteners, Edit. 36
  bolts, nuts, screws, Edit. 154, 158; Adv. 49, 54, 64, 66, 78, 88, 193
  locking, Adv. 49, 88
  pin, Edit. 140
Fiber, Adv. 159
Filters, Edit. 128; Adv. 42, 184
Fittings, pipe, tube and hose, Edit. 175; Adv. 96, 176, 190, 192
Fluid couplings, Adv. 76
Fluids, hydraulic, Edit. 140
Forgings, Adv. 143
Friction materials, Adv. 146

Gaskets, Adv. 46, 70, 160
Gear shaping, Adv. 182
Gears, Edit. 106; Adv. 9, 51, 163, 182, 193, 194
Generators, Adv. 177
Gray cast iron, Edit. 140
Guide rods, Adv. 27

Heaters, Adv. 168
Hose, metallic, Adv. 178
  nonmetallic, Adv. 96
Hydraulic equipment (see specific type)
Hydrofoils, Edit. 22

Instruments, Edit. 171; Adv. 174
Insulation, Edit. 139, 140; Adv. 74, 159
Inverters, Adv. 177

Jacks, worm gear, Adv. 173

Kinematics, Adv. 38

Latches, Edit. 38
Lubricants, Edit. 140
Lubrication equipment, Adv. 42

Machines (see specific type)
Magnetic amplifiers, Edit. 120
Magnetic materials, Edit. 139
Management, engineering, Edit. 28, 98
Meetings, Edit. 10, 39; Adv. 199
Metals (see specific type)
Motors, electric:
  fractional and integral hp, Edit. 157, 173; Adv. 58, 60, 62, 92
  gear motors, Adv. inside back cover
  synchronous, Edit. 169
  subfractional hp, Edit. 179; Adv. 1
  torque motors, Adv. 190

Nickel and alloys, Adv. 80

Packings, Adv. 46
Perforated metals, Adv. 158
Phosphors, Edit. 140
Pillow blocks, Adv. 195
Plant equipment, Adv. 189

MACHINE DESIGN is indexed in Industrial Arts and Engineering Index Service, both available in libraries, generally

MACHINE DESIGN Circle item number for information on products SEND COPIES OF FOLLOWING ARTICLES IN THIS ISSUE

SUBJECT INDEX (continued)

Plastics, Edit. 160, 172, 175, 177; Adv. 45, 61, 74, 189
Plastics molding, Edit. 113; Adv. 45, 162, 183
Plastics, reinforced, Edit. 113; Adv. 2, 45
Pneumatic equipment (see specific type)
Powder metallurgy, Edit. 139, 140
Precious metals, Edit. 139
Programing, Edit. 98
Pulleys (see also Sheaves), Adv. 15, 192
Pumps, hydraulic, Edit. 22; Adv. 141, 152, 181, 190
pneumatic, Adv. 190

Radiators, Edit. 10
Recorders, Edit. 182
Rectifiers, Edit. 139, 177
Reducers, speed, Edit. 154, 174, 176
Regulators, flow, Edit. 186
pressure, Adv. 42
Relays, Edit. 166, 174; Adv. 40, 155, 158, 166
Rheostats, Edit. 105
Roll forming, Adv. 167
Rolls, Adv. 27
Rubber, Adv. 46, 72, 86, 89, 165

Screws, power, Adv. 149
Seals, Adv. 16, 46, 70, 148, 165, 189, 191
mechanical, Edit. 140; Adv. 70, 151
Semiconductors, Edit. 139
Servos, Edit. 164
Shafts, Adv. 27
flexible, Adv. 164
Shapes, special, Adv. 45, 162, 183
Sheaves (see also Pulleys), Adv. 68, 192
Small parts, Adv. 183
Solenoids, Edit. 157, 172
Springs, Adv. 93, 191
Sprockets, Adv. 33
Starters, motor, Adv. 7
Steel, Adv. 11, 36, 56, 71, 85, 90, 95
stainless, Adv. 71, 172
strip, Adv. 172
Stress analysis, Edit. 139
Switches, Edit. 10

Tape, Adv. 192
Testing, Edit. 180, 182; Adv. 37, 189
Thermocouples, Edit. 139, 158; Adv. 189
Timers, Adv. 158
Tips and techniques, Edit. 112, 116, 134
Torque converters, Adv. 198
Transducers, Adv. 174
Transmissions, adjustable speed, Adv. 76
Transistors, Edit. 139
Tubing, Adv. 5, 36, 96, 157, 178

Valves, hydraulic, Edit. 157, 163, 172, 175, 178, 186
pneumatic, Edit. 157, 172, 178, 188; Adv. 39, 186

Washers, lock, Edit. 171; Adv. 184
Weldments, Adv. 83

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CIRCLE ITEM NUMBERS—Throughout the magazine, each advertisement carries an Item Number for use in requesting further information. All product descriptions, announcements and Helpful Literature items are also numbered, and for greater convenience are indexed below by Item Numbers.

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Index to New Parts & Helpful Literature

BY ITEM NUMBERS

HELPFUL LITERATURE—descriptions start on page 142

	ITEM NUMBER		ITEM NUMBER
Milling Techniques	601	High Alumina Ceramics	630
Instrument Photoprints	602	Explosive Power Units	631
Cartridge Ball Bearings	603	Use of Resistors	632
Aluminum Structural Shapes	604	Transfer Switches & Timers	633
Stainless Steels	605	Sleeve Bearings & Bushings	634
Magnetic Toggle Relay	606	Hoists & Cranes	635
Fluid Line Couplings	607	High Strength Aluminum	636
Lubrication Systems	608	High Vacuum Valves	637
Hard Rubber Fittings	609	Magnetic Amplifier	638
External Cotter Pins	610	Motor Starting Relays	639
Shaded Pole Motors	611	Rotary Gas Pumps	640
Air-Over Motors	612	Pressure-Vacuum Controls	641
Control System Components	613	Lighted Pushbutton Switches	642
Bearing Bronze	614	Miniature Power Connectors	643
Voltage Regulators	615	Metal Film Resistors	644
Insulating Varnish	616	Swivel Casters	645
Rack & Panel Connectors	617	Flexible Coupling	646
Pumps, Fluid Motors, Valves	618	FHP Motors	647
Electrical Insulation	619	Graph & Chart Tapes	648
Pump Motors	620	Electrical Insulation	649
Mechanical Tubing	621	Automatic Controls	650
Bronze Bearing Alloys	622	Right-Angle Gear Drives	651
Air Line Equipment	623	Variable Speed Drive	652
Spring Wire	624	Thermometer	653
Phosphating Analysis	625	High Temperature Material	654
Coated Magnet Wire	626	Explosive Valves & Latch Pins	655
Air Moving Units	627	Stainless Welding & Brazing	656
Epoxy Glass Laminates	628	Check Valves	657
Metallic Welded Bellows	629	Pressure Transducers	658

NEW PARTS & ENGINEERING EQUIPMENT—descriptions start on page 154

	ITEM NUMBER		ITEM NUMBER
Ball Bearings	659	Solenoid Valve	681
Gear-Reduction Unit	660	Polyvinyl-Chloride Plastics	682
Sandwich-Panel Fastener	661	Miniature Connector	683
Miniature Angle Counter	662	Small Motor	684
Solenoid Valves	663	Time-Delay Relay	685
Motors	664	Speed Reducers	686
Bendable Thermocouple	665	Extruded Vinyl Foam	687
Miniature Nuts	666	Coupling and Valve Unit	688
Teflon-Coated Foils	667	Floating-Hub Caster	689
Variable Capacitor	668	Transmission	690
Variable Capacitor	669	Selenium Rectifier	691
Electrical-Connector Clip	670	Epoxy Resins	692
Rotating Servo Components	671	Forged Needle Valves	693
Conveyor Belt	672	Clutch-Brakes	694
Hydraulic Cylinder	673	Servo Motor	695
Magnetic Toggle Relay	674	Pneumatic Function Generator	696
Diesel Engines	675	Audio-Circuit Modules	697
Cooling Blowers	676	Recorder-Controller	698
Photoconductive Cell	677	Power Pack	699
Synchronous Motor	678	Drafting Tables	700
Lockwasher	679	Whiteprinting Machines	701
Panel Meters	680		

MACHINE DESIGN
OCT. 2, 1958

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401	426	451	476	501	526	551	576	601	626	651	676	701	726	751
402	427	452	477	502	527	552	577	602	627	652	677	702	727	752
403	428	453	478	503	528	553	578	603	628	653	678	703	728	753
404	429	454	479	504	529	554	579	604	629	654	679	704	729	754
405	430	455	480	505	530	555	580	605	630	655	680	705	730	755
406	431	456	481	506	531	556	581	606	631	656	681	706	731	756
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410	435	460	485	510	535	560	585	610	635	660	685	710	735	760
411	436	461	486	511	536	561	586	611	636	661	686	711	736	761
412	437	462	487	512	537	562	587	612	637	662	687	712	737	762
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414	439	464	489	514	539	564	589	614	639	664	689	714	739	764
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416	441	466	491	516	541	566	591	616	641	666	691	716	741	766
417	442	467	492	517	542	567	592	617	642	667	692	717	742	767
418	443	468	493	518	543	568	593	618	643	668	693	718	743	768
419	444	469	494	519	544	569	594	619	644	669	694	719	744	769
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421	446	471	496	521	546	571	596	621	646	671	696	721	746	771
422	447	472	497	522	547	572	597	622	647	672	697	722	747	772
423	448	473	498	523	548	573	598	623	648	673	698	723	748	773
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413	438	463	488	513	538	563	588	613	638	663	688	713	738	763
414	439	464	489	514	539	564	589	614	639	664	689	714	739	764
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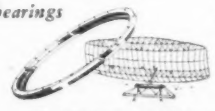

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K-581

Circle 413 on Page 19

Low-Altitude Flying . . .

hydrofoils

U. S. Navy Photograph

FLYING SAILBOAT speeds 35 mph in a 10 to 15-mph breeze; has automatic trim control. Mechanical computer and linkage system determine pitching moment of the sail on the hull and control the angle setting of the rear foil.

SHIPS—shape and speed, have shown little significant change in the past 50 years. During that time, tremendous advances have been made in the design of powerplants, and the performance curve on airplanes has soared out of sight. Fortunately, the vast pool of knowledge gained from years of aerodynamic research is currently proving to be a windfall to the designers of boats.

Now, boats with hydrofoils are going faster on less power than any conventional hull could ever do. And previous performance problems are rapidly being washed out.

Hydrofoils are far from new. F. W. (Casey) Baldwin and Alexander Graham Bell built a hydrofoil boat in 1919 that still inspires experienced men in the field. Powered by two 350-hp Liberty aircraft engines, the craft roared over various inland lakes at a record-breaking 70 mph. It was dismissed as a freak by most educated marine architects of the day. Unfortunately, the big boat had a tendency to porpoise (overactive aerodynamics)

HIGH AND DRY, an experimental Navy craft with retractable hydrofoils gives its crew a smooth, fast ride. Small wake created by foils gives illusion of slowness.

Revolutionary Designs . . .

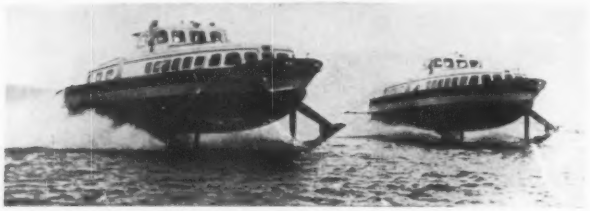
are on the drafting boards of marine architects. The reason: A spectacular breakthrough in the design of propellers that promises an immense increase in the speed of ships.

First reports on the new supercavitating propeller (MACHINE DESIGN, September 18, 1958) were released last month during the Second Symposium on Naval Hydrodynamics, sponsored by the Office of Naval Research. In describing the event, one expert declared that hull designers now have the greatest challenge since Ericsson invented the screw propeller.

The situation can be reasonably compared to the early development of jet aircraft. Propeller-driven airframes proved no aerodynamic match for the turbojet engine, just as conventional hulls are outdated by the new marine propeller.

Probably the most practical application at the moment is to install the propeller on a hydrofoil-equipped boat. Hydrofoils will also be of supercavitating design. Grumman Aircraft Corp. is planning a test of this combination within two years. The test craft will be approximately 100 ft long, weigh 50 tons, and will be powered by a gas-turbine engine. Speed range: 80 to 200 knots.

HYDROFOIL HOTROD, built by Grumman Aircraft Corp., shows excellent cornering characteristics. The 15-ft boat banks into high-speed turns, never skids. Foils are glass fibre, but will soon be replaced by aluminum.



PASSENGER LINERS with hydrofoils have already proved feasible. Ferries carrying 72 passengers have operated successfully for more than 2 years in the Messina-Straits area of Italy. Weighing 27 tons, the boats fly over the water at 50-mph speeds.

Flying on Water: Size Limitations

How big can a hydrofoil boat be? The fact that foil lift must equal the weight of the ship when flying leads to a simple equation:

$$P_s = \frac{6.9(VD)}{Cp(L/D)}$$

where P_s = shaft power; hp; D = displacement, tons; C_p = propulsive coefficient, and L/D = lift-drag ratio.

Assuming $C_p = 0.60$ and $L/D = 11.45$, the equation reduces to:

$$P_s = VD$$

Obviously hydrofoils belong on smaller craft. A 60-ton planing hull requires on the order of 6000 hp to make 45 knots. Equipped with hydrofoils, it would need only 2700 hp.

On the other hand, a 68,000-ton (fully loaded) Forrestal-class aircraft carrier would require 2,380,000 hp to fly on hydrofoils. This is more than nine times its installed power.

which seemed to bear out the experts' opinions.

For some reason, Mr. Bell discontinued his research, and little was done with hydrofoils in the U. S. until World War II.

During the course of the war, Naval officials became aware that small, fast boats had a definite mission in sea warfare. Boats were built, but plywood hulls hitting a 3-ft sea at 50 knots didn't provide the answer.

So necessity, newly acquired knowledge of airfoils, and the memory of 70 mph in 1919, prompted marine architects to refocus their attention on a point slightly above sea level.

Hydrofoils are accurately described as underwater wings. Their formula for lift is the same as that for airfoils:

$$L = C_L \frac{\rho}{2} V^2 S$$

where L = lift, C_L = coefficient of lift of the foil section, ρ = density of the fluid (water is about 800 times air), V = velocity of the foil, and S = effective area of the foil in the water.

The drag formula is the same as the lift formula with an appropriate C_D in the place of C_L.

Since the weight of the boat remains constant, control over lift has to be exerted once the hull has lifted clear of the water. Two methods have been developed:

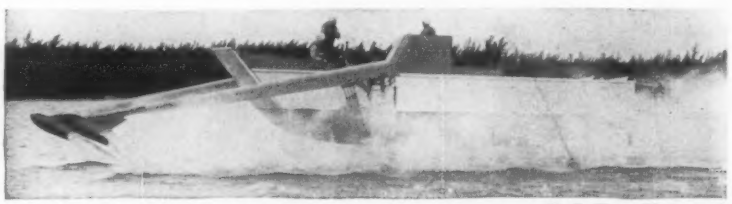
1. Surface-piercing foils (V-shaped, and/or ladder-like) give automatic height control. Active foil area is reduced as the craft rises above the surface. Lift ultimately equals the weight of the craft. Transverse and longitudinal stability are also attained automatically; the foil that dips when the craft heels or pitches provides added lift.

2. As the other alternative, angle of attack of submerged foils can be varied to control flying height. This, of course, involves the use of sensing and controlling mechanisms.

Gibbs & Cox, New York, have designed and built a hydrofoil system of this nature for the Navy. An autopilot is used to control the position of the boat and foils. The control system includes a height-sensing device, integrating gyros, accelerometers, and servomechanisms. Mounted on a 5-ton boat, the foil and control system have proved capable of supporting and controlling a 100-ton craft.

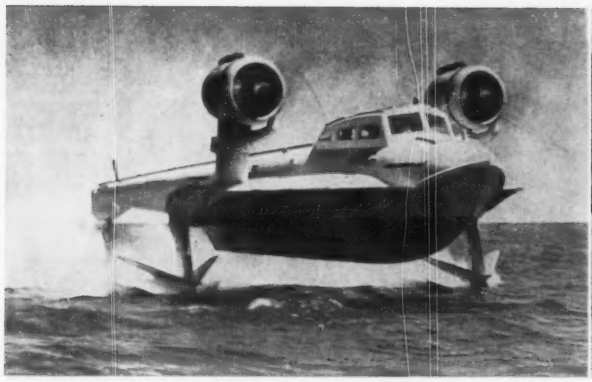
At the present time, a hydrofoil craft can go twice as fast as any boat of comparable size with the same installed power. A dramatic demonstration of this efficiency is provided by a 26-ft sailboat, built by Baker Engineering Co., Evansville, Wis. The craft flies 35 mph in a 15 mph breeze.

Scene of hydrofoils' most conspicuous commercial success today is in Italy. Regularly scheduled flying ferries, built by Rodriquez Shipyard, Messina, have carried

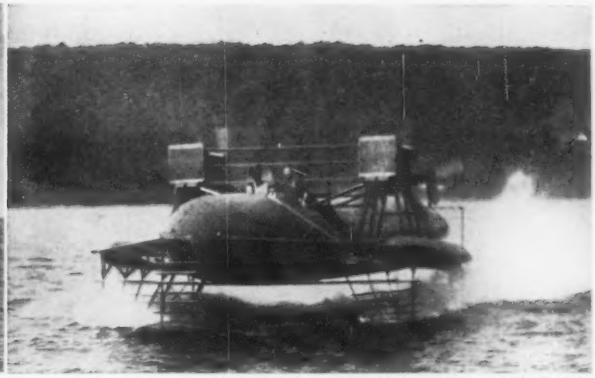


U. S. Navy Photograph

SKIS PROJECTED AHEAD of this 15-ton experimental Navy landing craft control the angle of attack of the main forward foil. Skis will eventually be replaced by a sensitive electromechanical height-sensing device now being developed. Miami Shipbuilding Corp. is building a turbine-powered model.



FASTEST OPEN-SEA BOAT in the world, according to Dynamics Development Corp., the XCH-4 Navy research vessel exceeds 70 mph in 3 to 4-ft seas. Riding qualities under these conditions rival an automobile.



Gilbert Grosvenor © National Geographic Society

PIONEER U.S. HYDROFOIL BOAT, the Bell-Baldwin HD-4 set a long-standing speed record of 70 mph in 1919. The boat weighed 5 tons; had a tendency to porpoise.

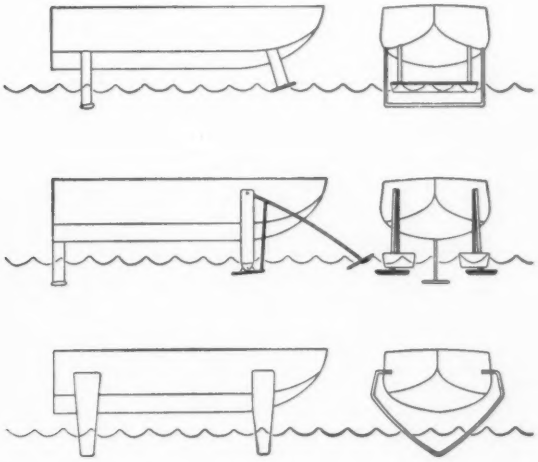
several hundred thousand passengers in two years of operation. Displacing 27 tons, the boats carry 72 passengers at top speeds of 50 mph. Rodriquez is ready to launch a 50-ton ferry with a passenger capacity of 150. Powered by two 1350-hp diesel engines, the boat is expected to cruise at 47 mph.

By far the most enthusiastic hydrofoil fan in this country is the Navy. From the appearance of some of its test craft, hydrofoils are being attached to anything that floats. Actually, the Navy is exceedingly interested in exploiting the speed potential of hydrofoils for antisubmarine work, mine laying, air-sea rescue, and coastal patrol. At the top of the list is a development program for LCVP's (Landing Craft, Vehicles and Personnel). Some of the landing craft used in World War II were sitting ducks for shore installations. Turbine-powered hydrofoil boats, maneuvering quickly at high speeds, would solve this problem. A high-performance seaplane hull utilizing hydrofoils is also a major requirement.

On the inland-lake front, civilian enthusiasm for hydrofoils is hardly widespread at the moment. For one thing, the concept is relatively new and needs introduction. Newness also extends to the manufacturing process, resulting in a disproportionately high cost. Another major problem is the fact that all hydrofoils available now come attached to a boat. No standard method of attaching foils has yet been developed.

Any minor setbacks in performance or cost will not dampen the enthusiasm of hydrofoil proponents however. Research by the Navy (who recently declassified a tremendous amount of hydrofoil data), and by industry, has produced solid evidence that hydrofoils offer a means of high-speed water travel undreamed of a few years ago. Working models are racking up valuable performance data, and a second generation of modern hydrofoil boats will soon be launched, to take advantage of gas-turbine powerplants, and supercavitating foils and propellers.

As the cost of superliners such as the *United States* continues to soar, the demand for smaller and much faster transatlantic craft may logically result. Hydrofoil craft of 1000 to 2000 tons that could make the trip in 24 hr offer a new horizon in travel.—C. E. Wise



Flying on Water: Three Ways

Grunberg System: Planing surface is mounted at the bow. A submerged hydrofoil aft supplies lift. The planing surface can be a flat plate, as shown, or one or more skis or pontoons. It acts as a balancing element, indirectly controlling angle of the aft foil which is attached rigidly to the hull.

Controlled Angle System: A planing surface riding ahead of the boat is linked to the main forward foil and changes the angle of attack of the main foil. Pitch of the hull controls the angle of the aft foil, which is fixed to the hull. Mechanical and/or electronic sensing devices and servo systems would adjust angle-of-attack of forward foils.

Controlled Area System: Foils fore and aft share the lift. Automatic height control is achieved, since active foil area is reduced as the craft rises above the surface. Main disadvantage: Quick change in center of gravity momentarily upsets equilibrium.

Super Currents Circulate Hot Sodium at 10,000 gpm

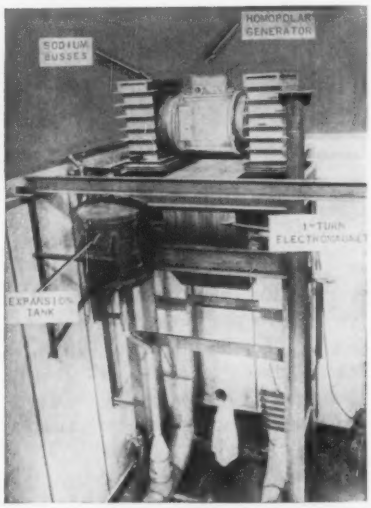
Pump Without Moving Parts Operates on 250,000 Amp

GENEVA—An old electrical machine with highly specialized characteristics—the homopolar generator—has staged a comeback in the nuclear age, according to staff scientists at the Argonne National Laboratory. The problem: How to circulate very hot, highly radioactive sodium through a nuclear power reactor at flow rates ranging up to 10,000 gpm. The spectacular solution: An outsized electromagnetic pump powered by a 250,000-amp homopolar dc generator in a structure 30 ft high and weighing 35 tons. Drive motor for the generator is rated at 1250 hp.

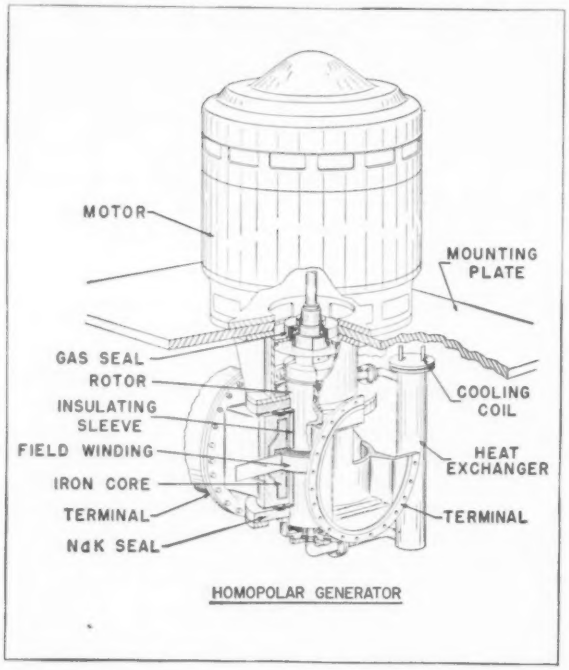
Construction details of pump and generator were revealed last week in a paper submitted for publication in the proceedings of the UN atom conference at Geneva. Authors of the paper—R. A. Jaross and the late Dr. A. H. Barnes—point out that the pump operates without moving parts. Pumping force is achieved by the interaction of a 250,000 amp current which passes through the sodium at right angles to a strong magnetic field. Because of the low voltage requirement of the pump—only 2.5 v—electrical breakdown of the ionized gas surrounding the pump in radioactive locations is eliminated.

Principle of the direct-current homopolar generator was first demonstrated by Faraday. The machine has two poles, but the conductors always cut lines of flux in the same direction. The resulting emf is unidirectional, allowing the use of simple slip rings instead of the commutator usually found in dc generators.

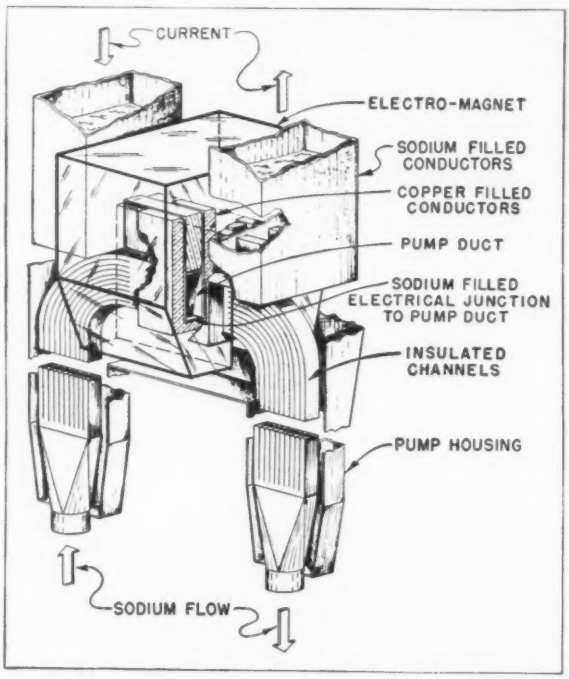
In the Argonne sodium pump, the homopolar generator is of the liquid brush type: A liquid metal alloy of sodium and potasium (NaK) serves as the current conductor between rotating and stationary members. Excitation for the generator field windings—comprising a 13-turn coil of heavy copper strap—is supplied by a separate 3000-amp source.



Pump and generator sections of the liquid-sodium pump are arranged vertically to reduce length of the sodium-filled current conductors.



Field winding of the homopolar generator—energized by a 3000-amp excitation source—sends magnetic flux through the rotating armature. Liquid "brushes" of sodium-potassium alloy pick up induced currents as high as 250,000 amp, transfer the current through rectangular sodium-filled conductors to the electromagnetic pump. Heavy copper bus bars form a single-turn energizing coil for the electromagnet while the sodium-filled junction leads the current vertically through the sodium duct. Interaction of the massive current with the magnetic field oriented at right angles provides the sodium pumping force.



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Circle 414 on Page 19

the ideal creative supervisor

part 2

By EUGENE RAUDSEPP
Research Consultant
Deutsch & Shea Inc.
New York

A SUPERVISOR has, at best, a difficult job. But the job is doubly difficult when he supervises a creative group. Maximum creative performance can be attained only when the supervisor understands and appreciates all the necessary ingredients of creative supervision.

This series of three articles is designed to define the characteristics of the "ideal" creative supervisor. It is based on the comments of a 105-man panel of experts on creativity—men who have wide experience in managing creative groups, and in teaching or researching creativity. Part 1 of the series was published in the September 18 issue of MACHINE DESIGN.

The Ideal Creative Supervisor Should

▶ Inspire and Encourage

Panelists were almost unanimous in saying that the main functions of the ideal supervisor were to stimulate, encourage, and enthuse. In several comments, it almost appears as if these were alone sufficient for eliciting creative performance. Here's how several panelists indicated the importance of encouragement and stimulation by the supervisor:

- *He is willing to encourage men and their ideas.*
- *He brings out the best work in people.*
- *He is a stimulating counsellor and teacher.*
- *He sincerely encourages imaginative approaches.*
- *He furnishes the inspiration that keeps things moving.*
- *He teaches and helps rather than polices.*
- *He strives to build up an atmosphere which encourages new ideas and changes.*
- *He has ability to be more enthusiastic than critical.*

To summarize, the supervisor should be a man who has contagious enthusiasm for research, who constantly encourages and stimulates his people to come up with new imaginative approaches, who welcomes innovation and change, and who takes a lively and active interest in their efforts and problems.

One panelist, Dr. Donald C. Pelz of the University of Michigan was particularly emphatic about the importance of the "active interest" the supervisor should display:

- *We are becoming more and more convinced that this active interest in the on-going work, combined with a hands-off policy concerning its direction, is one of the most fruitful things that a research chief can do—particularly with his younger personnel. But this is not an easy thing for a leader to do. A competent chief who keeps in touch with his subordinates' work finds it natural to impose his own ideas. Or, if he wants to give them a free hand, it is all too easy to leave them isolated. To achieve the proper balance between interest and isolation is a feat which requires a great deal of skill in human relationships.*

The Ideal Creative Supervisor Should

▶ Safeguard Areas of Freedom

As indicated by Dr. Pelz and several other panelists, the super-

visor should take great pains not to dictate approaches to problems, but rather to define the ultimate research goal in a general way. In this way, he encourages individual initiative and provides the necessary permissive atmosphere. Suggestions and ideas should be welcomed, and individuals should be allowed to relax their binding habit patterns and "let themselves go."

Incredible as it may seem, lack of individual initiative among scientists and engineers in many companies is due to the fact that they have never actually been impressed with the desirability of showing any. Many scientists feel they are not allowed to be responsible for the initiation of new activities. Thus, the supervisor must indicate to his creative people what is expected of them, what they are permitted to do, and the areas where they can exercise independent judgment and freedom.

Industrial organizations, perhaps, cannot afford much more than what someone has termed "controlled freedom." But even "controlled freedom"—assuming creativity is sincerely desired—should be broad enough to encourage venturesome approaches. The creative worker should not be closely scrutinized and required to account for every idea at every moment. The emphasis, in short, should be placed more on freedom than on control.

While research and engineering groups must have an awareness of objectives and time limits, creative workers should never be forced to work in an atmosphere of urgency which pressures them to find immediate solutions to problems. There is plenty of evidence that crash programs have inhibited more creative ideas than they have produced.

Recognition is growing that if creative people are to remain creative, they should be liberated from the harassment of daily detail so they can occasionally devote time to reading, thinking, and experimentation on problems of their own choice. Such activities, engaged in during unrelegated time, increase the fund of total experience upon which they can draw when creatively engaged.

W. John Upjohn, a director of Upjohn Co., in a recent speech, emphasized the importance of extra, unrelegated time and privacy for the creative individual to prevent him from becoming a skilled technician. He reported that in the Upjohn Co. creative individuals are allowed to spend one day in five on whatever they like.

This "20 per cent policy," according to Mr. Upjohn, has brought many tangible dollars-and-cents results to the company. Actually, several researchers spent their free time on some company problems abandoned by others as insoluble. Where the previous deliberate efforts carried out on company time had failed to produce results, researchers, working on their own free time, succeeded.

The most fallacious, ingrained, and harmful stereotype of management is that vigorous physical activity represents efficiency and productivity, whereas sitting and thinking is nothing but slothful idleness.

The Ideal Creative Supervisor Should

▶ Bolster Self-Confidence

In his supportive role, the ideal supervisor should also bolster the self-confidence of his group to insure sustained effort. Dr. Danzig suggests that the supervisor can do it "partially by instilling confidence in each individual's ability to come up with something good, partially by emphasis on the importance of the objective."

Self-confidence plays a tremendous role in creative research. Without it, the aspiring creative scientist or engineer will not do justice to his creative potential. Fear of criticism, fear of supervisor's or colleagues' opinions or disapproval, doubts about his own ability, fear of appearing too revolutionary or unusual—all of these feelings, or any single one of them, can inhibit or suppress creativity.

Aware of this, the ideal supervisor shows in action and speech that he has absolute confidence in his staff. Dr. English suggests that self-confidence could be induced through the "wonderful ego-building phenomenon of recognition." He states:

- *Since most people suffer from a feeling on inferiority, then recognition of the fact that an individual has something to give goes a long way toward making him feel that he can give it. Therefore, an organization must indicate to its talented person-*

How "Free" Is Your Creative Group?

Some soul-searching questions every creative supervisor should ask himself have been suggested by Dr. J. H. McPherson:

1 How comfortable are you in giving freedom to those who can handle it?

2 Are you afraid to delegate freedom and responsibility for fear the task will not be carried out according to your specifications?

3 Can you recognize those who mouth a need for freedom but who cannot handle it when it is given to them?

4 Can you recognize those who demand freedom but who actually need to improve control over their impulses?

5 How much opportunity do you give researchers for the selection of their own problems. Do you, at least, give a broad range of alternative problems, or offer some area of choice?

6 Have you helped establish a climate where it is permissible to sit and think without interruption and without the fear that sitting and thinking can be interpreted as wasting time?

nel that it expects each one of them to produce. This can be stated in such a way that it is not anxiety-producing but is, instead, ego-building. Do not say, "we expect you to produce or we will throw you out," but say, "we have employed you to be creative and productive for us, and we want to help you all we can to do this thing."

The creative supervisor should, of course, have confidence in his own ability. When the group embarks on a new problem, he should be ready to take the calculated risks involved and, in the words of one panelist, "be able to maintain a positive and optimistic approach toward the problem and the many possible solutions." No-holds-barred freedom of action, which includes freedom to make mistakes, should be given each member of the team at the inception of a creative task when the lines of approach have still not been fixed.

Knowing when to ask stimulating and searching questions and when to listen, the creative supervisor spurs and encourages bold thinking and confident rehearsal of the many ideas that occur. It is here that the supervisor's ability to suspend critical judgment is put to a test. Nothing can inhibit creativity more than critical judgment or evaluation applied prematurely in the process of creative ideation. Judgment, evaluation, and criticism certainly have their place, but only at the conclusion and not during, or at the beginning of, a creative venture.

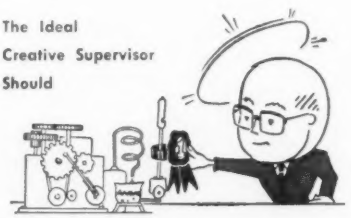
This ability to suspend evaluation until the dominant idea has crystallized, applies not only to the idea itself, but as Prof. John E. Arnold of Stanford University points out, to "economic limitations, mechanical feasibility or to the adaptability of man to machine."

Although the supervisor's optimism should be tempered with reality, at the initial stages of the project he should be more optimistic than realistic. A basic optimism and a stubborn refusal to give up—no matter how great the difficulties initially encountered—are two very important qualities in the creative supervisor's personality make-up.

Many people are unable to work for extended periods at a difficult problem because of a tendency to early discouragement when no solutions emerge. As William J. J. Gordon of Arthur D. Little Inc. recently remarked in a speech:

• *Solutions to many problems remain undiscovered because inventors ran out of creative energy just when they were on the brink. . . . It is just when we strike these seemingly impenetrable bastions that we tend toward despair, like others before us . . . and it is just then that we are on the verge of solution.*

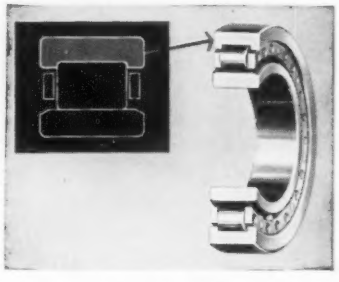
Because creative problems yield their secrets with reluctance, the creative supervisor should stubbornly resist his group's inclination to s e r i o u s discouragement. He should provide the members of his team with all the moral support that he can muster at this difficult stage of the creative process.



▶ Respect Others' Ideas

The ideal supervisor should have no feelings of insecurity about his position. He should be able to accept others' ideas and willingly admit that these are frequently better than those he could have come up with. As Dr. Cartier points out:

Loggers' "weight-lifter" tests bearing stamina!



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Circle 415 on Page 19

• *Too many supervisors fail to take the advice of their underlings because of an unconscious tendency to feel they alone should retain the power of supervision and decision. Yet it is in the nature of modern technology that some of his men should know more about certain things than he does.*

The creative supervisor, then, is not only able to recognize an original concept, but he is also able to recognize unselfishly the merits in ideas and concepts his team suggests. Dr. Danzig suggests that the supervisor be more "goal-oriented" than "status-oriented"; he should be "more interested in seeing the problem solved than in gaining the personal glory."

According to a number of panelists, the ideal supervisor is a humble man, humble about his particular area of knowledge and convinced that other specialists can contribute significantly to solving a problem creatively. One panelist, a manager of a research and development division at a big company, even suggested that occasional self-effacement on his part might not be so bad. According to him, the supervisor should frequently "let the other man think it is his idea, even though the idea originated with the supervisor."

Whether this extreme is actually advisable or not is a moot question, especially in view of the survey findings that an effective supervisor has to retain his group's technical respect. Be that as it may, the supervisor should never dominate his group; when he himself produces ideas, he should do it without showing off. Several panelists even insisted that he be accepted not so much as a leader than as a colleague who is on a par with the members of his group.

Concluding article in this series will be published in the October 16 issue of MACHINE DESIGN.

Atom Angles

Nuclear ship performance, economically competitive with conventional vessels, was forecast in technical papers recently presented at the Second Nuclear Ship Symposium, sponsored by the AEC and the Maritime Administration. Development of a boiling water reactor, described by engineers of the General Electric Co., is expected to bring operating costs of a nuclear ship within 10 per cent of conventional ship powerplants. Talks at the meeting also pointed to outmoding of the *Savannah* design by 1960, the time she is scheduled to start operation.

• • •

Explosive for atomic bombs, plutonium 239, is now being used as a fuel in a nuclear reactor. This is the first time plutonium has powered an AEC reactor at substantial power levels. The Materials Testing Reactor (MTR), at the Commission's National Reactor Testing Station in Idaho, normally fueled with uranium 235, will be operated with plutonium and brought up to a power level of 30,000 kw. The experiment with a plutonium-fuel loading is expected to advance the technology of plutonium fuel-element handling and fabrication.

• • •

Closed-cycle reactor plant will make more fuel than it consumes. Experimental Breeder Reactor II (EBR-II), now under construction at Argonne National Laboratory's Idaho Div., is scheduled to go "critical" in 1960. It is designed to generate 62,500 thermal and 20,000 electrical kw.

"Used" fuel, poisoned in the reactor by accumulation of waste fission products, will be reprocessed and refabricated in the fuel cycle plant. It will then be inserted back into the reactor core, where the plutonium will release its "man-made" energy.

"Breeding" takes place inside the reactor. As each atom of uranium 235 is split (fissioned) by one neutron, it releases an average of 2.5 neutrons. One neutron is needed to split another atom and maintain the chain reaction. This leaves approximately 1.5 neutrons available for other purposes. About 1.2 neutrons are absorbed into the highly fertile uranium 238, which then produces fissionable plutonium 239. The remainder of the neutrons are lost by leakage or are nonproductively absorbed.

• • •

Reduced capital costs are emphasized in design of the Yankee Atomic Electric Co.'s nuclear powerplant at Rowe, Mass., R. J. Coe, vice president of Yankee Atomic, told delegates at the Second UN Conference on the Peaceful Uses of Atomic Energy. He indicated that after the first few years of operation, the total power cost is expected to be about 14 mills per kw-hr. "At the nominal plant rating of 134,000 kw," Coe explained, "the annual capacity cost is about $70 per kw, and, for an annual plant factor of 80 per cent, the capacity cost is 10 mills per kw-hr." He added that net fuel cost is estimated at about 4 mills per kw-hr, bringing total power cost to 14 mills per kw-hr.

Tells of Special Demands In Guided Missile Business

UTICA, N. Y.—Ever consider getting into the guided missile business? Some idea of the special factors involved that make this work either attractive or unattractive to your particular organization have been spelled out by Robert J. Gutheim of the Office of Guided Missiles in a recent address before the New York State Defense Procurement Conference.

• Missiles utilize almost every science and technology to the maximum.

• They demand high, uniform, and repetitive quality.

• Environmental criteria are much more severe than for conventional weapons.

• Missile tolerances are generally at least ten times more exacting than tolerances of the weapons they replace.

• The materials used, the tolerances, and the quality establish peculiar manufacturing needs.

• Users have found it justified to pay for premium quality because infallibility is the goal.

• Obsolescence rate is high.

• Long shelf life, operability, and preventive maintenance must be built into the weapon.

In commenting on the volume of current missile business, Mr. Gutheim pointed out that, dollarwise, the U. S. missile program has grown from an obligation rate of $60 million in 1947 to $6 billion this year.

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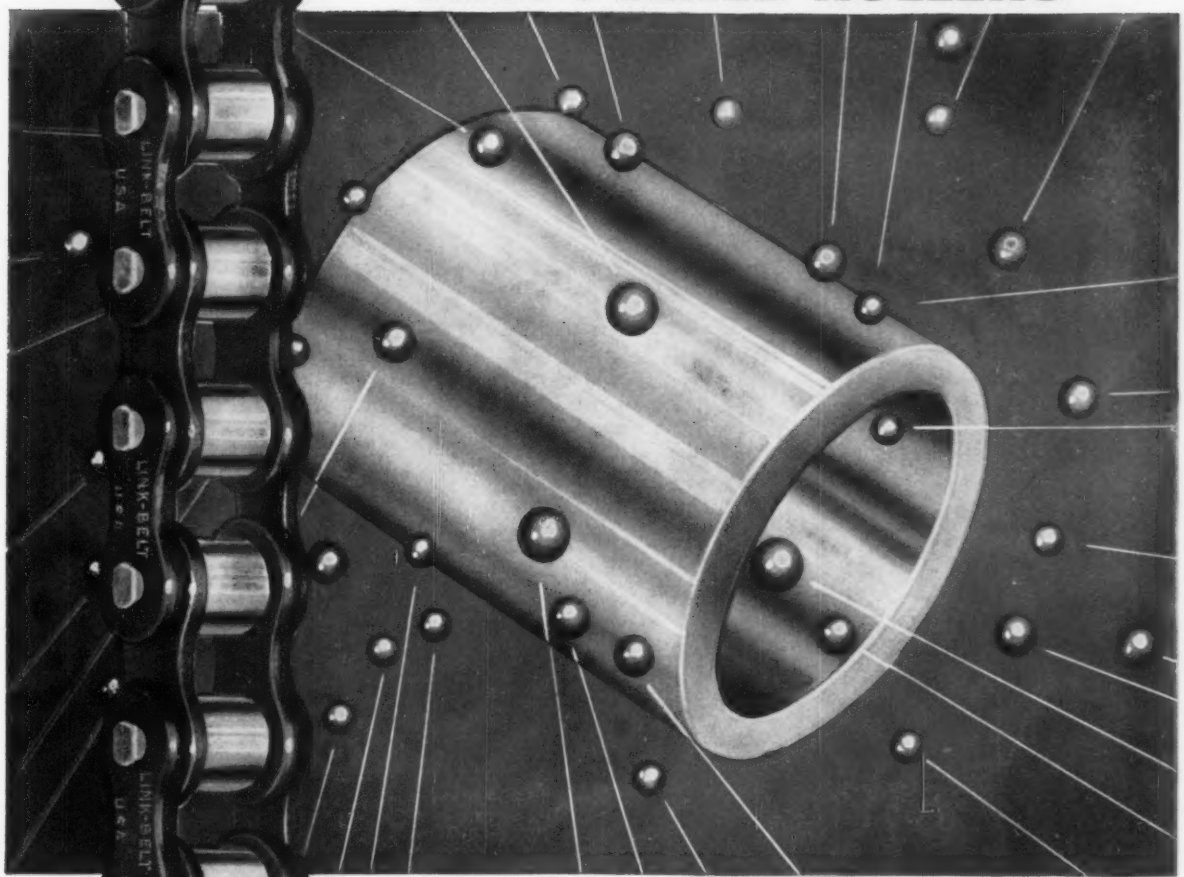

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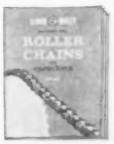

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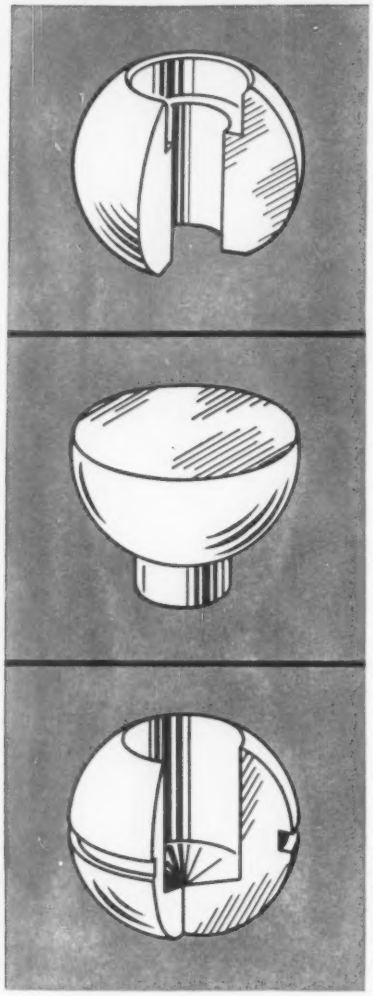

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ELECTRON FARM ON THE MOON, made up of giant sheets of coated plastic overlaid with wire mesh, would generate about 1500 kw per acre. Such lunar powerplants, according to officials of Westinghouse's Air Arm Div., will be needed in the future because moon bases will have to be absolutely self-sufficent. Principle of the solar power station is simple: when the sun's rays strike the photosensitive coating on the plastic sheets, electrons are emitted and collected by the wire mesh. Closing the circuit between the grid and the coated surface gives a current flow. Key factor in the operation of such a device is the existence of a vacuum on the moon.

HOT JETS AT THE ROTOR TIPS permit this new cargo helicopter to lift about twice the payload of shaft-driven craft of the same size (6300 lb all-up weight). Pressure-jet burners mounted on each of the three blade tips spin the rotor. Air for combustion, supplied by three gas-turbine compressors, is ducted through rotor hub and blades to the jets, where fuel is injected and burned. Since no counter torque is imposed on the fuselage, the craft needs no tail rotor. Power shafting, gear box, and clutch are also eliminated. Cargo is carried suspended from a pilot-controlled cargo hook. Twelve passengers can be carried on toboggan seats which attach to the under fuselage and are enclosed against the elements. Designated Model 120, the new copter was designed and built by McDonnell Aircraft Corp.

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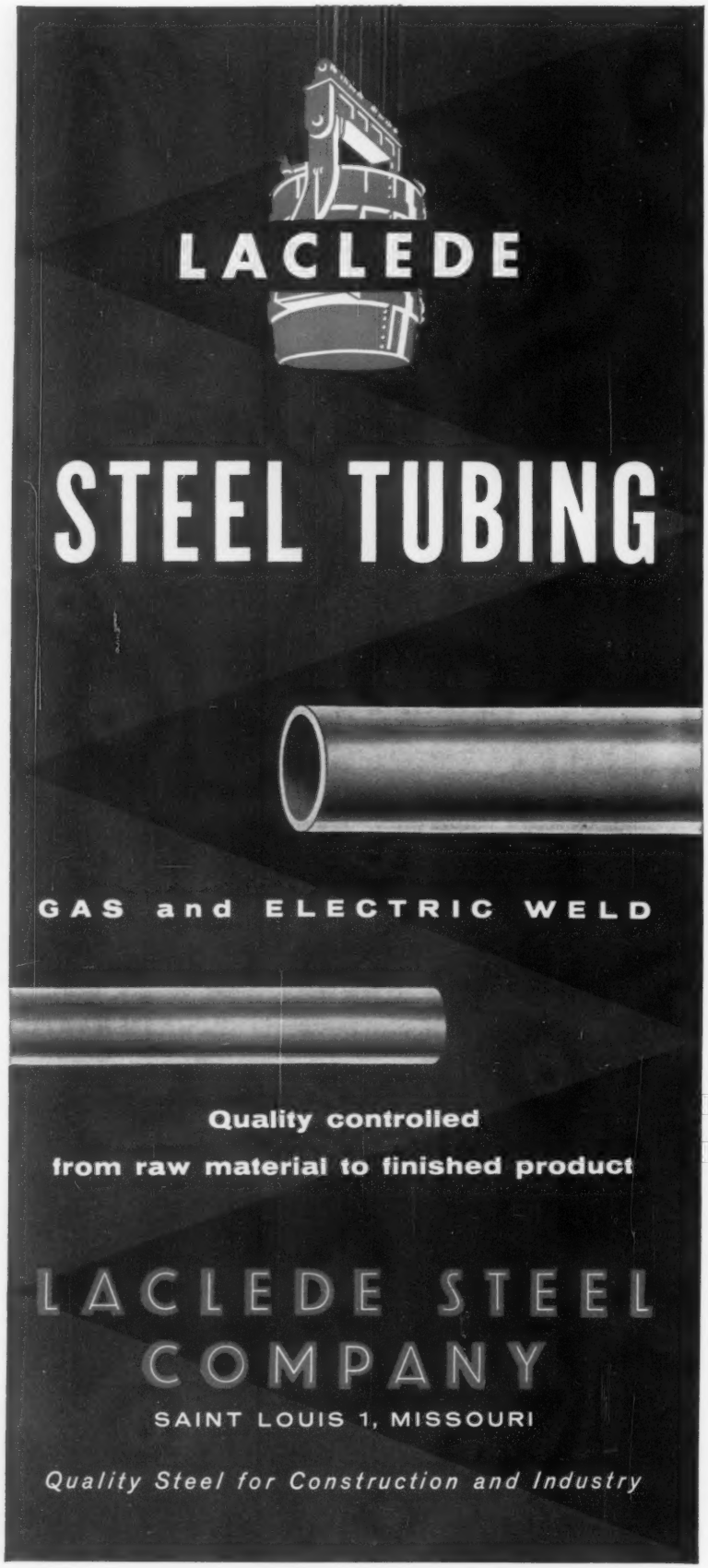
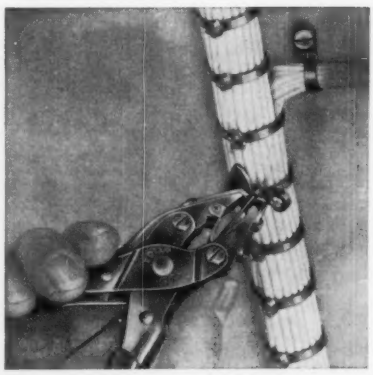
In Canada: Hughes Owens Company, Ltd., Montreal





NYLON TIE speeds cable lacing. New cable ties make up tightly without damage to wire insulation. Installation is made within about 5 sec as contrasted with some string ties that take 30 sec to install. A simple installing tool automatically cuts the nylon tie to proper length and locks it in place.

Develop Heat-Transfer Fluid For Ebullient Cooling

Boiling Liquid Circulates Without Coolant Pump

MIDLAND, MICH.—Development of the first heat-transfer medium specifically intended for use in ebullient cooling promises distinct advantages in cooling large stationary, internal-combustion engines.

Advantages of ebullient cooling—which is cooling by means of a boiling heat-transfer medium—are uniform engine temperature, faster engine warmup, automatic circulation and temperature control of the coolant, elimination of the water pump, reduction of corrosion, increased lubricant life, and possible use of cheaper, sulfur-bearing fuels.

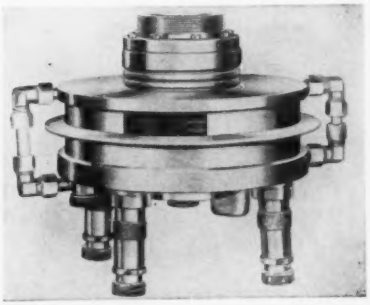
The heat-transfer medium, Dowtherm 209, developed by the Dow Chemical Co., is recommended for use in a 53 per cent (by weight) solution in water. This mixture is said to give freeze protection down to about − 45 F. According to the company, it gives freeze protection both in the engine and in the condensate return line.

Ebullient cooling, although known for more than 50 years to have distinct advantages over conventional cooling methods, has in the past received only limited ac-

Circle 419 on Page 19

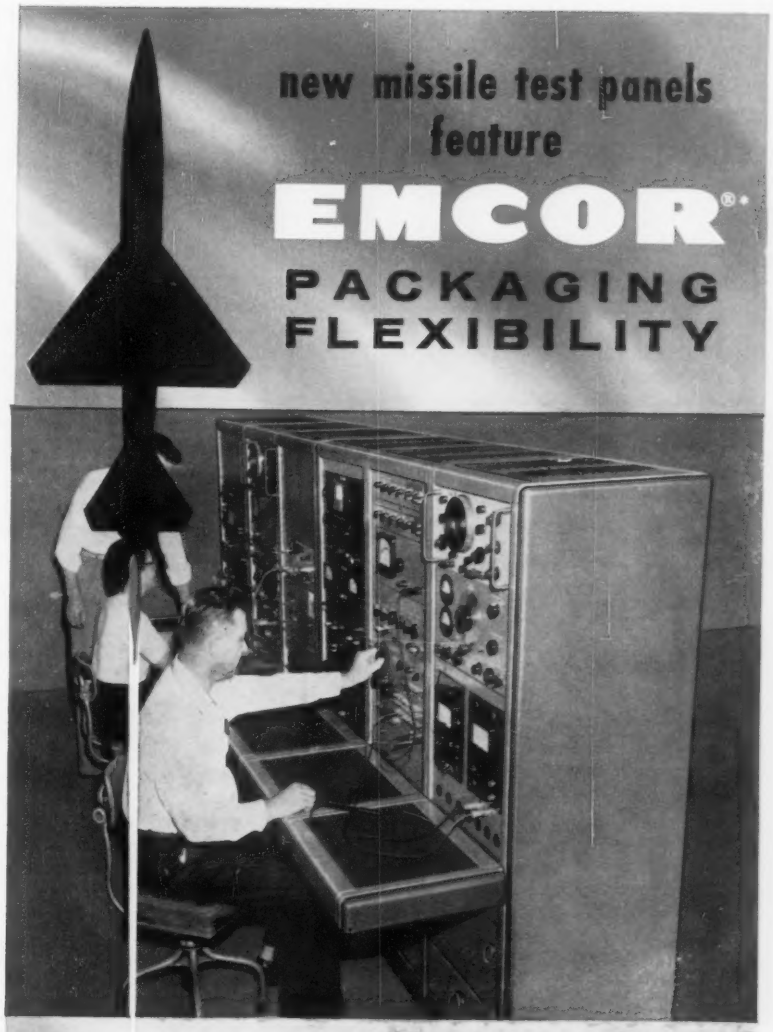
ceptance due to cold weather problems. Water has generally been used as a coolant, but must have a freeze-point depressant when temperatures drop to freezing or below. Attempts to use a standard antifreeze liquid such as ethylene glycol have not been generally successful, since this material will not azeotrope (form a constant boiling mixture) with water. Though water in the engine may itself be protected, vapors produced by the boiling mixture contain only water, which can freeze in the condensate return line.

According to the company, most conventionally cooled engines can be converted for ebullient cooling. Ordinarily no pump is needed, since circulation is by natural convection.



NEW COOLANT makes possible the design of high-power transmitting tubes that can operate at temperatures below 0 C with essentially the same power output as that obtained with water cooling at temperatures above 0 C. Low-temperature cooling in RCA tube is accomplished by inert Fluoro-chemical FC 75, produced by the Chemical Products Group, Minnesota Mining and Mfg. Co., St. Paul, Minn.

Impersonating an enemy bomber is the job of a small electronic lens in the Navy's Kingfisher target missile. The ball-shaped device, known as a Luneberg lens, focuses radar pulse signals in much the same way that light is focused. It provides, in effect, a phantom radar image of a big supersonic bomber, which can be easily tracked by search and homing radar. Lockheed Aircraft Corp. adapted the lens for drone duty to test the Talos missile.



Test panels designed and instrumented by test equipment engineers and builders of Lear, Inc., Grand Rapids, Michigan, assure reliability standards of the Lear Stable Platform being used in the initial guidance system of Boeing's long-range IM-99 Bomarc missile. The test panels feature the flexibility of EMCOR's most modern concept in metal cabinetry ... THE EMCOR MODULAR ENCLOSURE SYSTEM. Of uniform size, the test panel frames can easily be bolted, unbolted and rearranged to quickly meet changing production demands. EMCOR's engineering mastery of the design in metal cabinetry makes possible the arrangement of groups of intricately wired instruments, indicators, dials and electronic scopes for easy visual and manual operation while reducing environmental fatigue and strain.

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Circle 420 on Page 19

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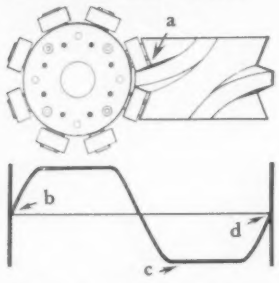
DESIGN CONSIDERATIONS

Critical Points in Acceleration Characteristics of Indexing Devices

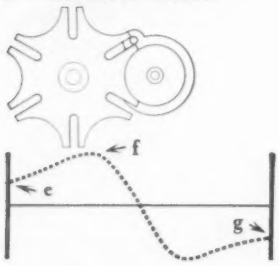
Maximum speeds of production machines are frequently affected by performance limitations of their indexing mechanisms. The efficiency of the indexing mechanism, itself, is dependent upon the amount of shock, vibration and other dynamic forces involved in the starting, stopping and rate of change from maximum acceleration to maximum deceleration.

FIG. 1 · · FERGUSON DRIVE



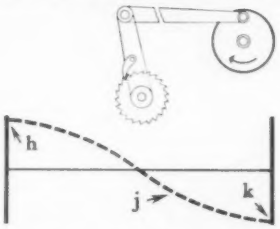
The acceleration curves of such mechanisms provide a graphic means of evaluating and comparing dynamic conditions that affect the performance of the indexing device and the machine. The Ferguson Drive in Fig. 1 is a cam indexing mechanism employing preloaded bearing followers rolling along a tapered cam rib. Two followers are in contact with the rib at all times (a) maintaining a zero backlash condition and an accuracy of .001″ without auxiliary locating devices. This Drive features a modified trapezoid acceleration characteristic . . . a combined cycloidal and gravity curve. The Ferguson Drive has an initial force of zero (b) and a smooth, sinusoidal increase. Its maximum acceleration value (c) is very low and the change through maximum deceleration to zero (d) is gradual. These smooth indexing characteristics of the Ferguson Drive permit operation of production machinery at speeds as high as 2,000 RPM, if necessary, with a minimum of 8,000 hours operation while maintaining extreme precision and zero backlash.

FIG. 2 · · GENEVA DRIVE



The six-stop geneva drive shown in Fig. 2 is representative of the geneva family in that its dynamic forces are instantaneously applied and the initial acceleration force is fairly high (e) with an even higher maximum acceleration (f). The change to maximum deceleration is gradual but there is an almost instantaneous stop (g). When operated at high speeds, geneva drives wear out quickly and cause heavy vibrations that seriously affect the life of the machine and product quality.

FIG. 3 · · RATCHET & CRANK



The rachet and crank has a distorted cosine acceleration curve (a true cosine curve is illustrated in Fig. 3) with an extremely high initial acceleration (h). The descent to maximum deceleration (j) is gradual but, as with the geneva drive, stopping is instantaneous (k). Even with auxiliary braking action, overtravel is extreme and accuracy is very poor. Rachet and crank devices have very limited use in modern production machines.

FIG. 4 · ·

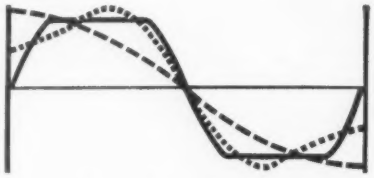
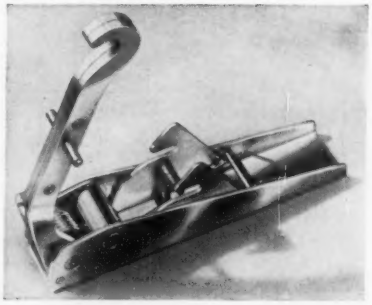


Fig. 4 shows the curves of the three mechanisms on the same diagram. Note that only the Ferguson Drive has an initial force of zero and the lowest maximum acceleration value combined with a gradual change to maximum deceleration. *This is why the Ferguson Drive does what no other indexing device can do!*

• SEND FOR CATALOG

Complete information about the Ferguson Drive is available in the form of an easy-to-use catalog containing load ratings and dimensions of many standard units, drawings and installation photos. There is a copy for every design engineer . . . for your copy write: **Ferguson Machine Corp., 7818 Maplewood Industrial Court, St. Louis 17, Missouri.**

ENGINEERING NEWS



BERYLLIUM latch meets 1000-lb static, tensile-strength requirement. Made by Hartwell Aviation Supply Co., Los Angeles, the latch is a hook type used to fasten a removable radome. The beryllium-copper alloy furnishes required nonmagnetic characteristics, coupled with good strength-to-weight ratio, corrosion resistance, and formability.

PULLING 16 TONS up 30-percent grades is the performance capability of Ford's 160-hp gas-turbine truck engine. Two major obstacles in the widespread use of automotive gas turbines are overcome in the design of the experimental powerplant: Turbine-wheel cost has been reduced from several thousand dollars to less than $100; heat-exchanger performance has been refined to the point where fuel consumption is almost competitive with conventional piston engines. In operation, the heat exchanger transfers heat from turbine exhaust to combuster-inlet air. Fuel demand in the burner is thus reduced and exhaust-gas temperature is lowered below the "pedestrian singe point."

Circle 421 on Page 19

DIRECT FLAME of blow torch can't damage this jacketed cable. Reflective asbestos jacket, manufactured by the Zippertubing Co. of Los Angeles withstands temperatures to 3000 F with no ill effects. Zipper closure facilitates assembly.

Meetings

AND EXPOSITIONS

Oct. 13-14—

Fifth Conference on Mechanisms to be held at Purdue University, West Lafayette, Ind. Sponsors are the Purdue School of Mechanical Engineering and MACHINE DESIGN. Further information can be obtained from the Editor, MACHINE DESIGN, Penton Bldg., Cleveland 13, Ohio.

Oct. 13-15—

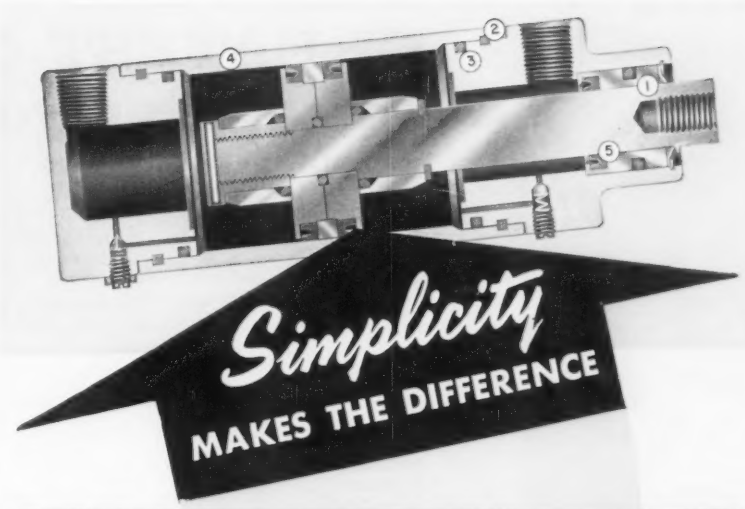
American Institute of Electrical Engineers Tenth Annual Machine Tool Conference to be held at the Statler-Hilton Hotel, Hartford, Conn. Additional information can be obtained from Mr. William P. Carpenter, Superior Electric Co., 83 Laurel St., Bristol, Conn.

Oct. 13-15—

National Electronics Conference to be held at the Hotel Sherman, Chicago. Sponsors are American Institute of Electrical Engineers, Institute of Radio Engineers, and Illinois and Northwestern Universities. Additional information can be obtained from Rudolph E. Hornacek, Illinois Bell Telephone Co., 208 W. Washington St., Chicago 6, Ill.

Oct. 13-15—

American Society of Mechanical Engineers—American Society of Lubrication Engineers Fifth Annual Lubrication Conference to be held



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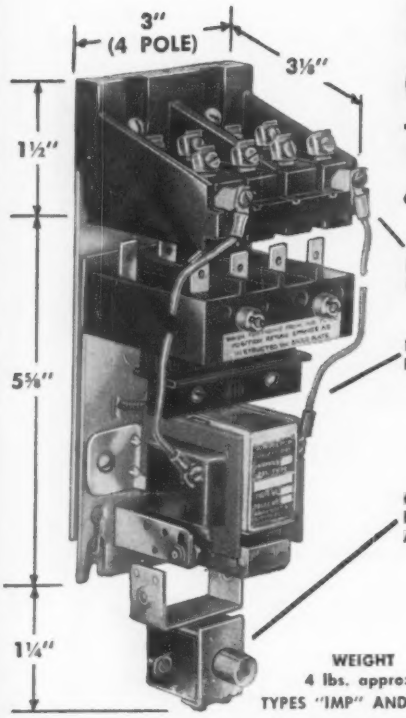

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at the Hotel Statler, Los Angeles. Further information can be obtained from ASME headquarters, 29 W. 39th St., New York 18, N. Y.

Oct. 16-17—

National Conference on Industrial Hydraulics to be held at the Hotel Sherman, Chicago. Further information can be obtained from Raymond D. Meade, Director of Extension and Co-operative Education, Illinois Institute of Technology, 3300 S. Federal St., Chicago 16, Ill.

Oct. 16-18—

Foundry Equipment Manufacturers Association. Annual Meeting to be held at The Greenbrier, White Sulphur Springs, W. Va. Additional information is available from association headquarters, 1 Thomas Circle, Washington 5, D. C.

Oct. 18-21—

American Society of Industrial Designers. Fourteenth Annual Meeting to be held at Bedford Springs Hotel, Bedford, Pa. Additional information can be obtained from Mr. H. W. McHose, Barber & Baar Associates Inc., 270 Madison Ave., New York 16, N. Y.

Oct. 20-22—

Society of Automotive Engineers Inc. National Transportation Meeting to be held at Lord Baltimore Hotel, Baltimore. Further information can be obtained from SAE headquarters, 485 Lexington Ave., New York 17, N. Y.

"I like the way Alberts uses his head."

Oct. 22-24—

Society of Automotive Engineers Inc. National Diesel Engine Meeting to be held at Lord Baltimore Hotel, Baltimore. Additional information can be obtained from SAE headquarters, 485 Lexington Ave., New York 17, N. Y.

Oct. 23-25—

National Society of Professional Engineers. Fall Meeting to be held at St. Francis Hotel, San Francisco. Further information is available from NSPE headquarters, 2029 K St. N.W., Washington 6, D. C.

Oct. 26-31—

American Institute of Electrical Engineers. Fall General Meeting to be held at the Penn-Sheraton Hotel, Pittsburgh. Further information is available from AIEE headquarters, 33 W. 39th St., New York 18, N. Y.

Oct. 27-31—

American Society for Metals. National Metal Exposition and Congress to be held at the Public Auditorium, Cleveland. Additional information can be obtained from ASM headquarters, 7301 Euclid Ave., Cleveland 3, Ohio.

Oct. 28—

Ultrasonic Manufacturers Association. Annual Meeting to be held at the Hotel Cleveland, Cleveland. Additional information can be obtained from UMA headquarters, 271 North Ave., New Rochelle, N. Y.

Oct. 29-30—

Computer Applications Symposium to be held at the Morrison Hotel, Chicago. Sponsor is the Armour Research Foundation of Illinois Institute of Technology. Further information can be obtained from Dr. Frederick Bock, Electrical Engineering Research Dept., ARF, 10 W. 35th St., Chicago 16, Ill.

Oct. 30-31—

Aircraft Electrical Society. Fifteenth Annual Display of Aircraft Electrical Equipment to be held in the Pan Pacific Auditorium, Los Angeles. Additional information can be obtained from society headquarters, 3540 Wilshire Blvd., Los Angeles, Calif.

Nov. 5-6—

Society of Automotive Engineers Inc. National Fuels and Lubricants Meeting to be held at The Mayo, Tulsa, Okla. Additional information is available from SAE headquarters, 485 Lexington Ave., New York 17, N. Y.

Nov. 10-12—

Steel Founders' Society of America. Thirteenth Technical and Operating Conference to be held at the Pick-Carter Hotel, Cleveland. Further information can be obtained from society headquarters, 606 Terminal Tower, Cleveland 13, Ohio.

Nov. 12-14—

Society for Experimental Stress Analysis. Annual Meeting to be held at the Sheraton-Ten-Eyck Hotel, Albany, N. Y. Further information is available from SESA, P. O. Box 168, Cambridge 39, Mass.

Nov. 17-18—

Conference on Magnetism and Magnetic Materials to be held at the Sheraton Hotel, Philadelphia. Conference is sponsored by the American Institute of Electrical Engineers, in co-operation with the American Physical Society, the Institute of Radio Engineers, the Metallurgical Society of AIME, and the Office of Naval Research. Further information can be obtained from Mr. C. J. Kriessman, Remington Rand Univac, 1900 W. Allegheny Ave., Philadelphia, Pa.

Nov. 17-21—

Society of the Plastics Industry Inc. National Plastics Exposition and Annual Conference to be held at the International Amphitheatre, Chicago. Further information can be obtained from society headquarters, 250 Park Ave., New York 17, N. Y.

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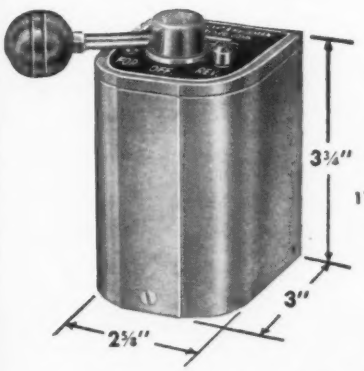

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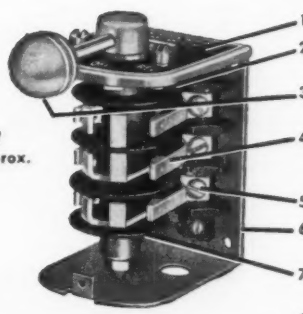

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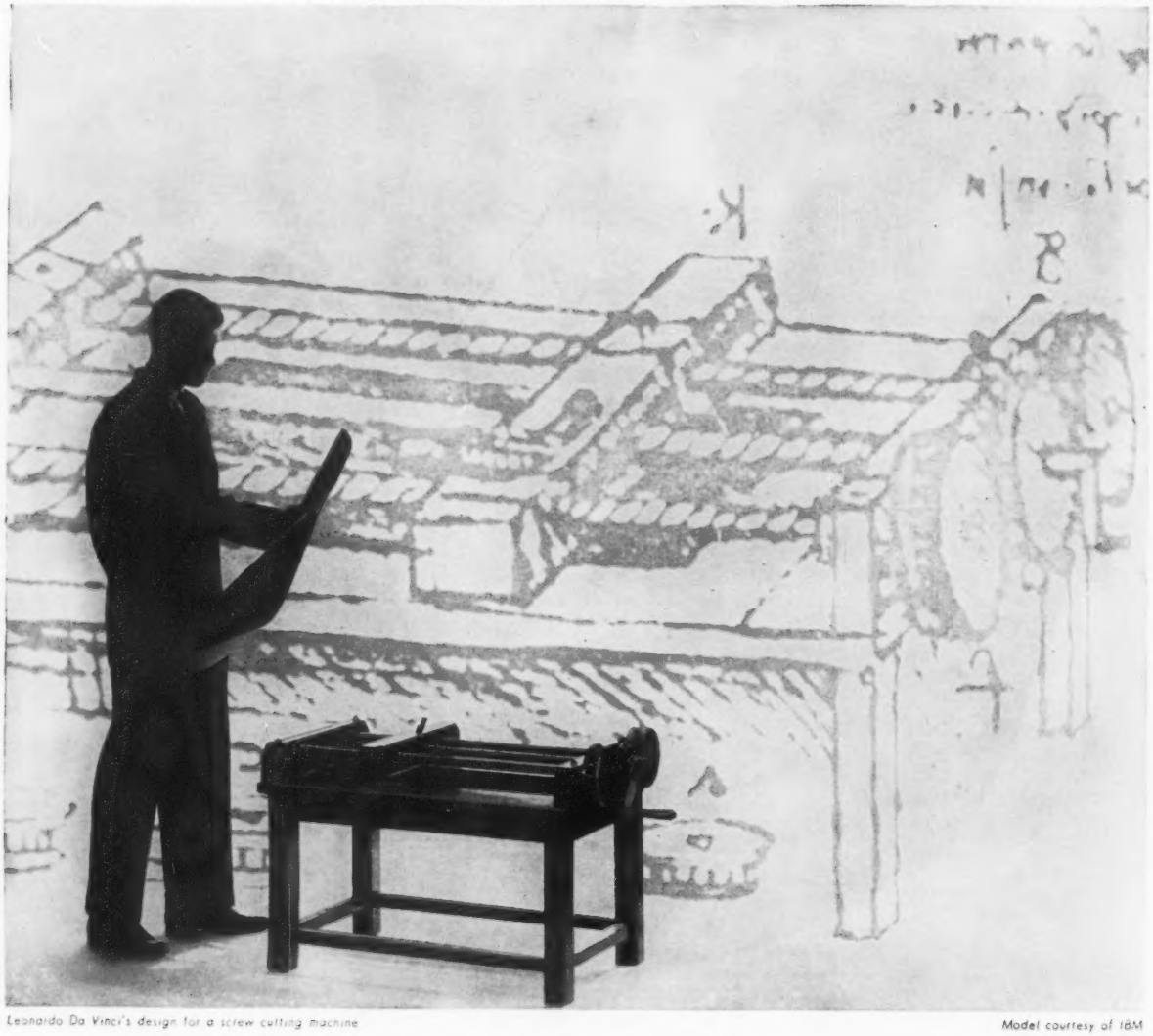

Leonardo Da Vinci's design for a screw cutting machine *Model courtesy of IBM*

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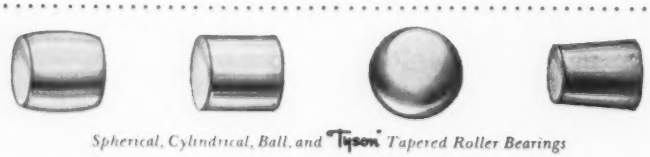

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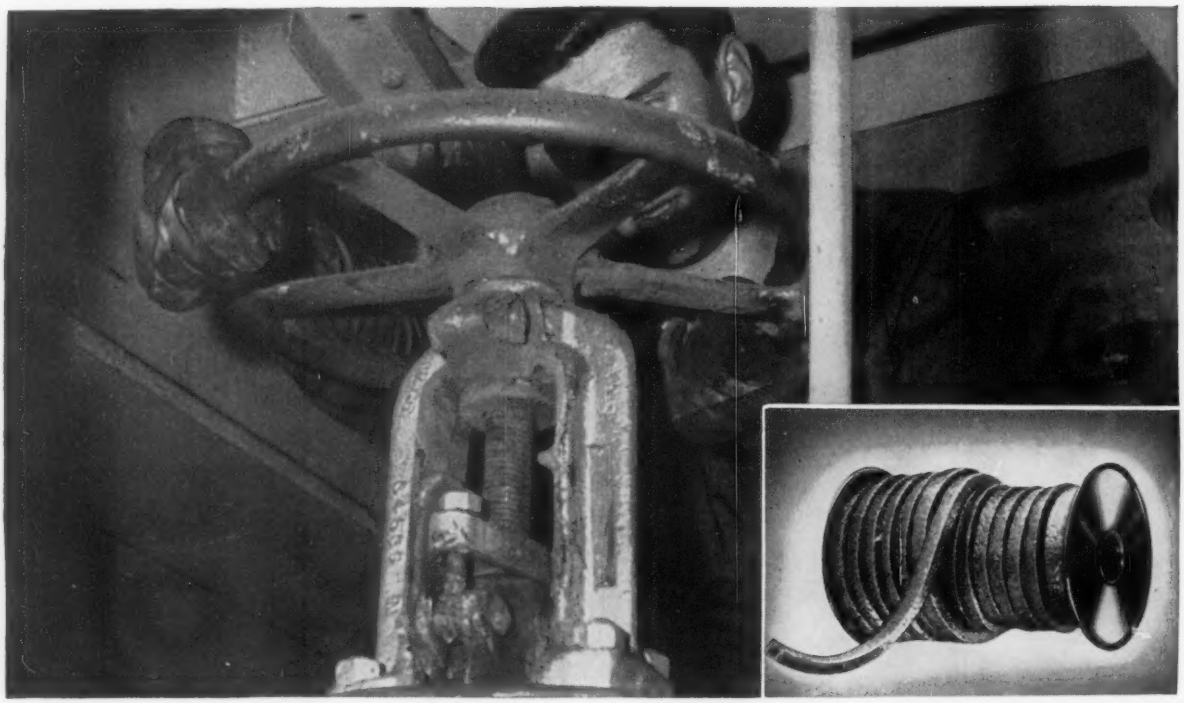

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R/M High Temperature Valve Stem Packings—reliable solution to your hot problems

Today's boilers produce more heat and more pressure. They also produce more packing problems. To get reliable performance at temperatures as high as 1000°F or higher, specify R/M High Temperature Valve Stem Packings.

R/M's experienced engineers designed these packings to meet your toughest present and future needs. They eliminated practically all of the organic materials which break down under heat. The result is a packing which provides outstanding heat resistance and low volume loss. Solid lubricants are ground in during manufacture—you will find thorough compounding no matter where you cut into the packing. R/M uses braided asbestos—reinforced with Monel or Inconel wire to give you maximum extrusion resistance.

R/M High Temperature Valve Stem Packings are available in several types, for use with steam, hot oil, or hot gases. One of these types is ideal for your requirements. Call on the R/M engineers for their specific recommendations.

The complete R/M line includes packings and gasket sheets for use with gases, water, steam, oil, chemicals, solvents and food products. Feel free to call on R/M's experienced engineers for help in your packing problems.

R/M

Brake Blocks, Linings and Clutch Facings

Mechanical Packings and Gaskets

Abrasive and Diamond Wheels

Industrial Drive Belts

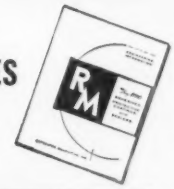
Industrial and Automotive Hose

Conveyor Belts

Circle 428 on Page 19

SPECIALISTS IN ASBESTOS, RUBBER, SINTERED METAL, ENGINEERED PLASTICS

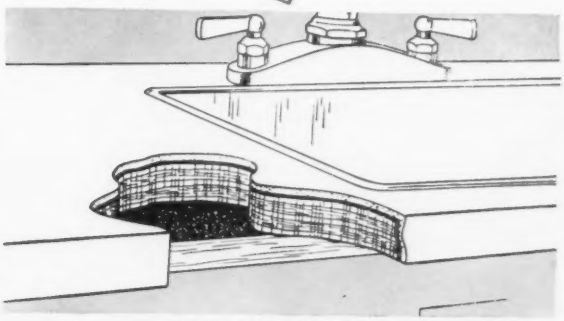
ADHESIVES



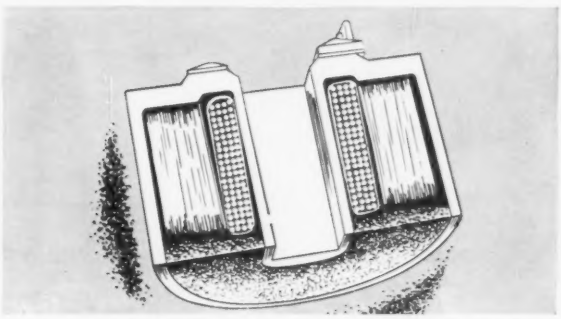
Send today for free copy of R/M Bulletin No. 700 on Ray-BOND adhesives, protective coatings and sealers.
Adhesives Department
Raybestos-Manhattan, Inc.
Bridgeport, Conn.

RUBBER

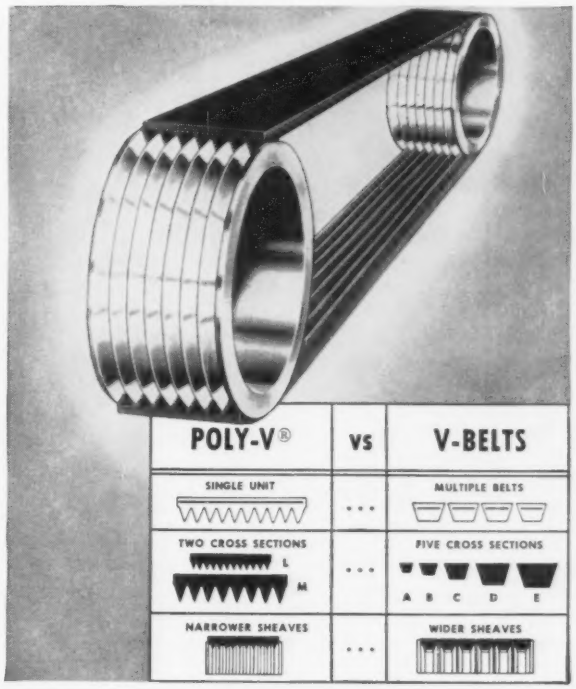
Write today for free booklet shown: full details on a wide variety of industrial rubber products.
Manhattan Rubber Division
Raybestos-Manhattan, Inc.
Passaic, N.J.



Bonding cabinet top to base



Sealing hundreds of wires with an R/M encapsulating compound



R/M Ray-BOND® Adhesives for faster production—lower costs

Ray-Bond Adhesives, tailored to the performance needs and the fabrication techniques of the individual manufacturer, are meeting widely varied requirements in products as diverse as aircraft engines and submarine cables, band saws, textiles and other porous materials. Adhesive bonding can cut your assembly costs, speed production, and simplify fabrication problems. It eliminates rivets and other fasteners, provides better heat conductivity, increases the life of friction members, and permits more effective bonding of dissimilar materials.

R/M offers you the benefit of its more than 20 years of experience with bonded assemblies for varied applications. Feel free to call on our engineers for help.

Put more power in less space with R/M Poly-V® Drive

Unique design of its single, parallel V-ribbed belt gives R/M Poly-V Drive* *twice* the tractive surface of a conventional multiple V-belt drive. This means Poly-V delivers up to 50% more power in the same space as a V-drive or equal power in as little as ⅔ the space! R/M Poly-V permits a more compact, lighter weight drive with less shaft overhang. Just two belt cross sections meet *every* heavy duty drive design requirement.

For light duty, single groove drive applications specify R/M FHP V-belts. Patented micro-positioned strength member and density controller make these the smoothest running V-belts made. Run quieter, cooler—and with less vibration. They're ideal for all kinds of motorized appliances, pumps and power tools. Whatever the drive design problem, rely on R/M specialists for the solution.

*Poly-V is a registered Raybestos-Manhattan trademark.

RAYBESTOS-MANHATTAN, INC.

FACTORIES: Passaic, N.J. • Bridgeport, Conn. • Manheim, Pa. • Paramount, Calif. • No. Charleston, S.C. Crawfordsville, Ind. • Neenah, Wis. • Peterborough, Ontario, Canada

Rubber Lined and Covered Equipment

Sintered Metal Friction Elements

Asbestos Textiles

Industrial Adhesives

Teflon Tape, Packings, Sheets, Rods, Tubes

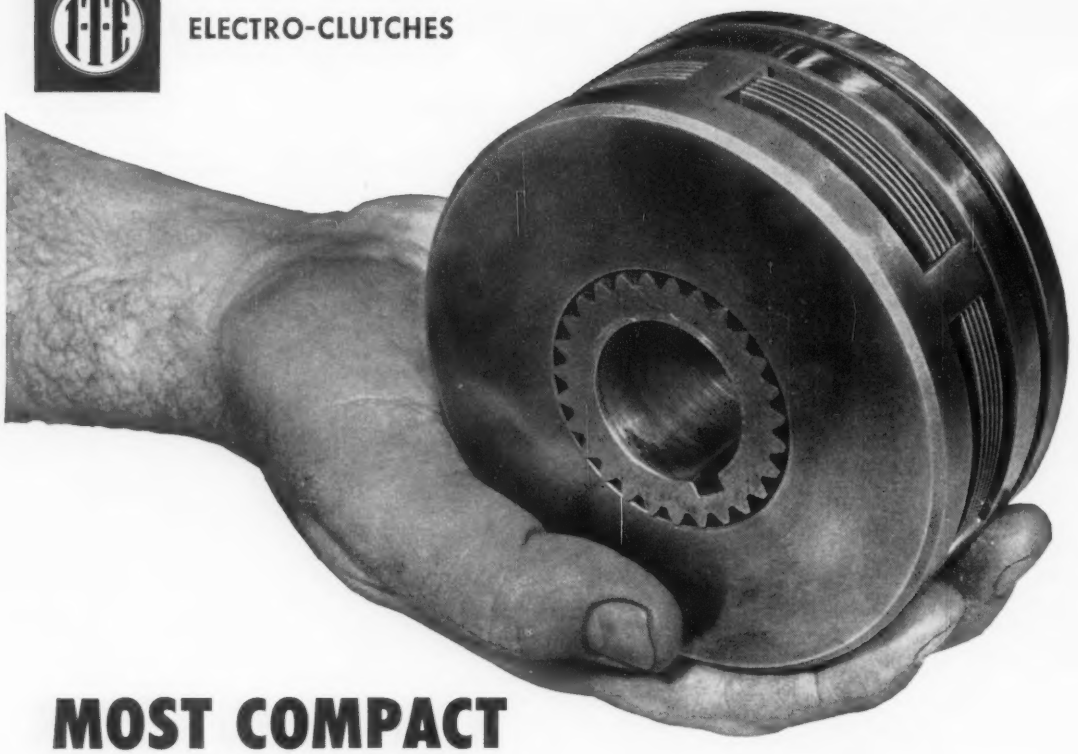
Engineered Molded Rubber and Plastics

R/M

Circle 429 on Page 19A

Circle 430 on Page 19A

ELECTRO-CLUTCHES



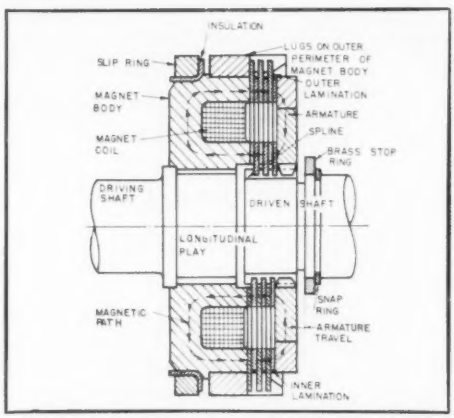
MOST COMPACT

The extra compactness in I-T-E Electro-Clutches means you can get more of them into the same space. This can mean more speed and feed changes for your machines; or it can mean simply a lower cost transmission and housing construction.

Patented closed magnetic circuit. Unlike other clutch types, I-T-E Electro-Clutches feature a patented closed magnetic circuit. Flux lines travel through—not around—the unique all-steel, interleaved laminations to produce tremendous torque in small space. The same laminations also provide the clutching surfaces, giving greater clutching area.

Most durable. The all-steel laminations in I-T-E Electro-Clutches naturally outlast other clutching materials such as plastics, sintered metals, or friction discs. At the same time, no air gap is needed. Hence I-T-E Electro-Clutches are adjustment free and give high, uniform torque throughout their long life. Since they operate in oily conditions, there's virtually no friction loss when disengaged —and heat is better dissipated.

I-T-E Electro-Clutches are available in 60 different models covering a wide range of torque ratings. All operate on safe, dependable 24 v d-c. Write for complete information. I-T-E Circuit Breaker Company, Transformer & Rectifier Division, 19th & Hamilton Sts., Philadelphia 30, Pa.



Principle of operation. Alternate laminations key with perimeter lugs and splined shaft respectively. Rotate freely until magnet coil is energized. Magnetic flux attracts the armature, compressing the laminations with great force, engaging clutch.

Drawing above illustrates type "d" internal drive—photo illustrates type "C" external drive.

I-T-E Electro-Clutches are already in use by these leading companies:

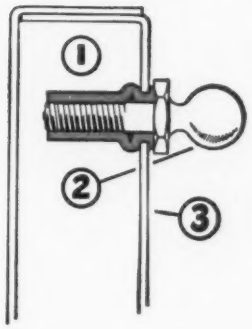
Bullard Fosdick Sundstrand
Giddings & Lewis

I-T-E CIRCUIT BREAKER COMPANY
PHILADELPHIA, PENNSYLVANIA

Circle 431 on Page 19

B.F.Goodrich

B. F. Goodrich Rivnuts® solve 3 fastening problems at once!

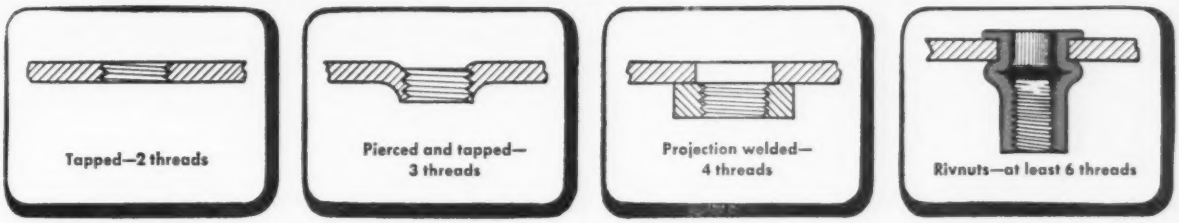


A RIVET WAS NEEDED for doors of metal cabinets that 1) could be installed from one side only, 2) would serve as a nut plate for a knob attachment and 3) could be installed after enameling. B. F. Goodrich Rivnuts proved the perfect answer.

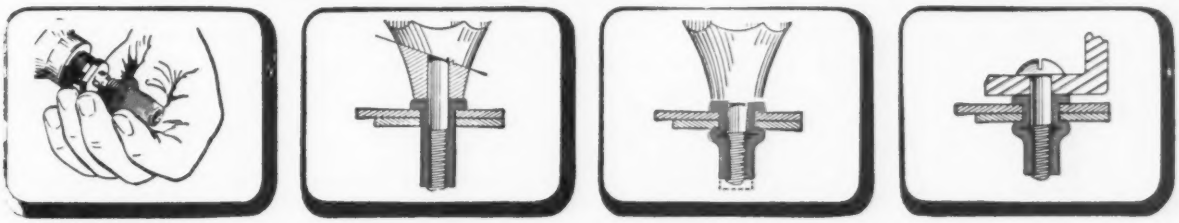
A flat-head Rivnut is inserted in the sheet metal door. Working from one side, one man can upset Rivnuts in seconds with easy-to-operate heading tool. Bulge formed in Rivnut shank grips the metal tightly. The knob of the catch is then threaded into the clean, still-intact Rivnut threads. Rivnuts are installed after enameling—without marring the finish.

B. F. Goodrich Rivnuts, the only one-piece blind rivets with threads, save many man-hours on the job. If you have a fastening problem, why not put it up to B. F. Goodrich engineers?

Compare these 4 methods of putting screw threads in thin sheet metal:



Rivnuts provide at least 6 clean threads in one simple operation!



1 Rivnut is threaded onto pull-up stud of a manual or pneumatic heading tool.

2 Rivnut is inserted—head firmly against work—tool at right angles to work.

3 Tool lever operates pull-up stud, forming a bulge in the Rivnut shank.

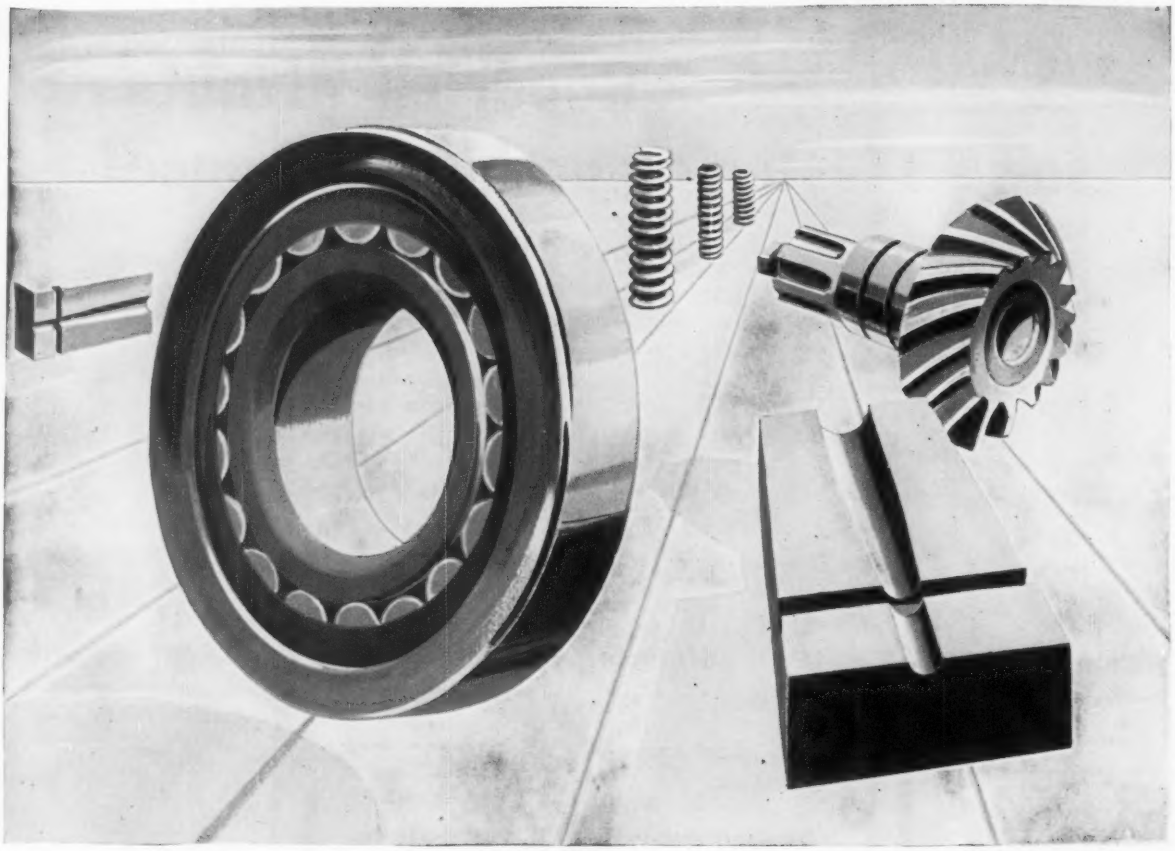
4 After upset, Rivnut threads are still clean and intact, ready for screw attachment.

SEND NOW FOR FREE RIVNUTS DEMONSTRATOR

Demonstrates with motion how you can use Rivnuts to fasten TO and fasten WITH. Explains construction, gives proved applications. Write for your free copy today to *B.F. Goodrich Aviation Products, a division of The B. F. Goodrich Company, Dept. MD-108, Akron, Ohio.*

B.F.Goodrich *aviation products*

Circle 432 on Page 19



Vacuum-melted alloys make parts stronger . . . give them operational dependability and longer life. Can a General Electric vacuum-melted alloy solve a design problem for you?

General Electric vacuum-melted alloys open vast new areas for mechanical design

G-E alloys have remarkably improved mechanical properties . . . are consistently pure and easier to fabricate

Notable advances in the design of aircraft propulsive systems have already been made possible by the development of vacuum-melted metals by the General Electric Company. And these better alloys can now make radical designs feasible in other mechanical fields.

Melting metals in a near-perfect vacuum makes them cleaner, essentially free from inclusions, impurities, gases, and oxides. Entirely new metals can be alloyed that could not even be made by air melting methods.

These superior properties of G-E vacuum-melted alloys include improved ductility, making otherwise unworkable metals easy to forge, weld or form; more uniform properties, giving operational reliability to machine components; and superior fatigue properties to give springs and diaphragms longer service life and consistent performance at high temperatures and stresses. And vacuum melting permits improvement in corrosion and oxidation resistant alloys because larger quantities of reactive metals can be used than is possible with air melting techniques.

General Electric vacuum-melted alloys can now be designed and produced to exacting specifications with consistently predictable properties and dependable life. You can order them in sheets, bars, billets and forgings.

Our metallurgical engineers are ready to help you select – or design – vacuum-melted alloys to meet your specifications. For more information – or the assistance of a G-E engineer – call or write: *Metallurgical Products Department of General Electric Company, 11159 E. 8 Mile Ave., Detroit 32, Michigan.*

Progress Is Our Most Important Product

GENERAL ELECTRIC

Circle 433 on Page 19

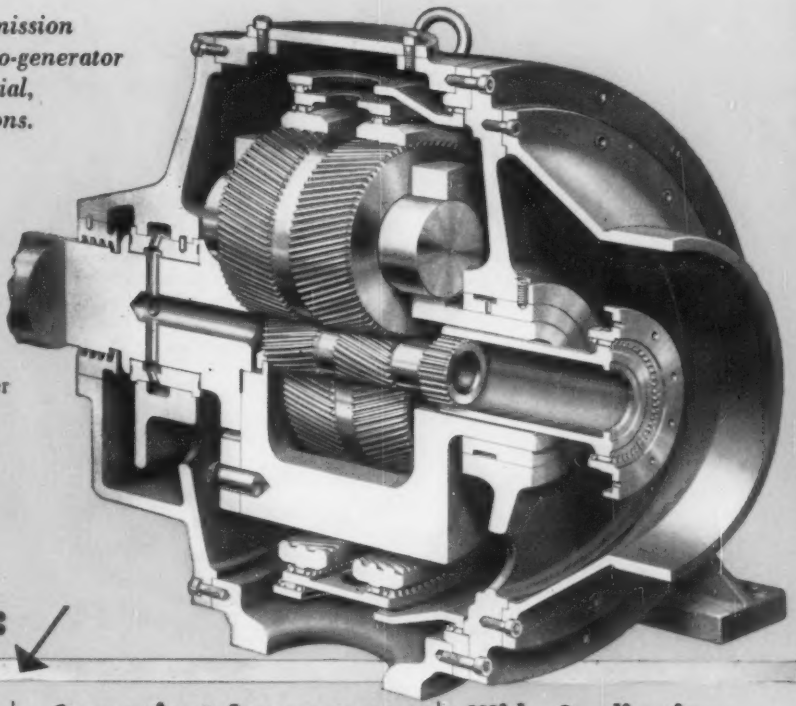
DE LAVAL-STOECKICHT
PLANETARY GEAR

...for high speeds...high horsepower

Proved in hundreds of installations abroad totalling over 3,000,000 horsepower—now available in America!

For all high torque power transmission applications such as pump turbo-generator and compressor drives in industrial, municipal and marine installations.

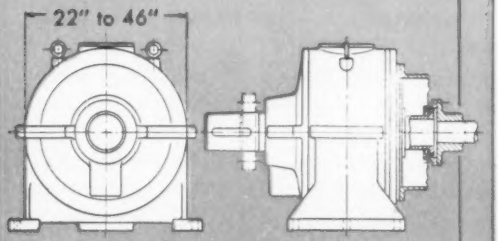
This cutaway view of the De Laval-Stoeckicht Planetary Gear shows how it provides flexibility for proper load distribution throughout the gear members. The thoroughly proved and tested design is completely reliable in transmitting high horsepower for high speed applications. • Highest efficiencies (98% or higher)...no high speed bearings...less friction losses.



Check These Advantages:

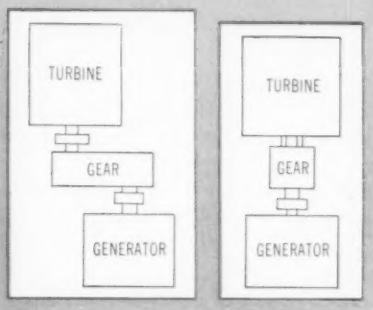
Small Size—Light Weight

Compact—low weight per hp. Sizes range from 22" to 46" in diameter, depending on horsepower requirements. Example: 5000 hp planetary unit weighs 1700 lbs. against 6000 lbs. for conventional gear.



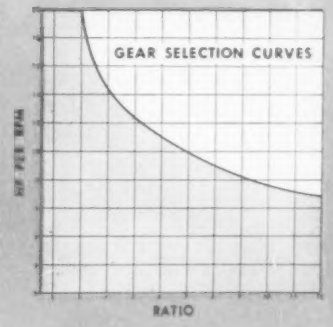
Convenient Arrangement

Co-axial or "in-line" arrangement of gear members takes up far less space than parallel axis gears of equivalent horsepower rating.



Wide Application

Capacity range shown in shaded area on chart below. For other applications, contact your De Laval Sales Engineer.



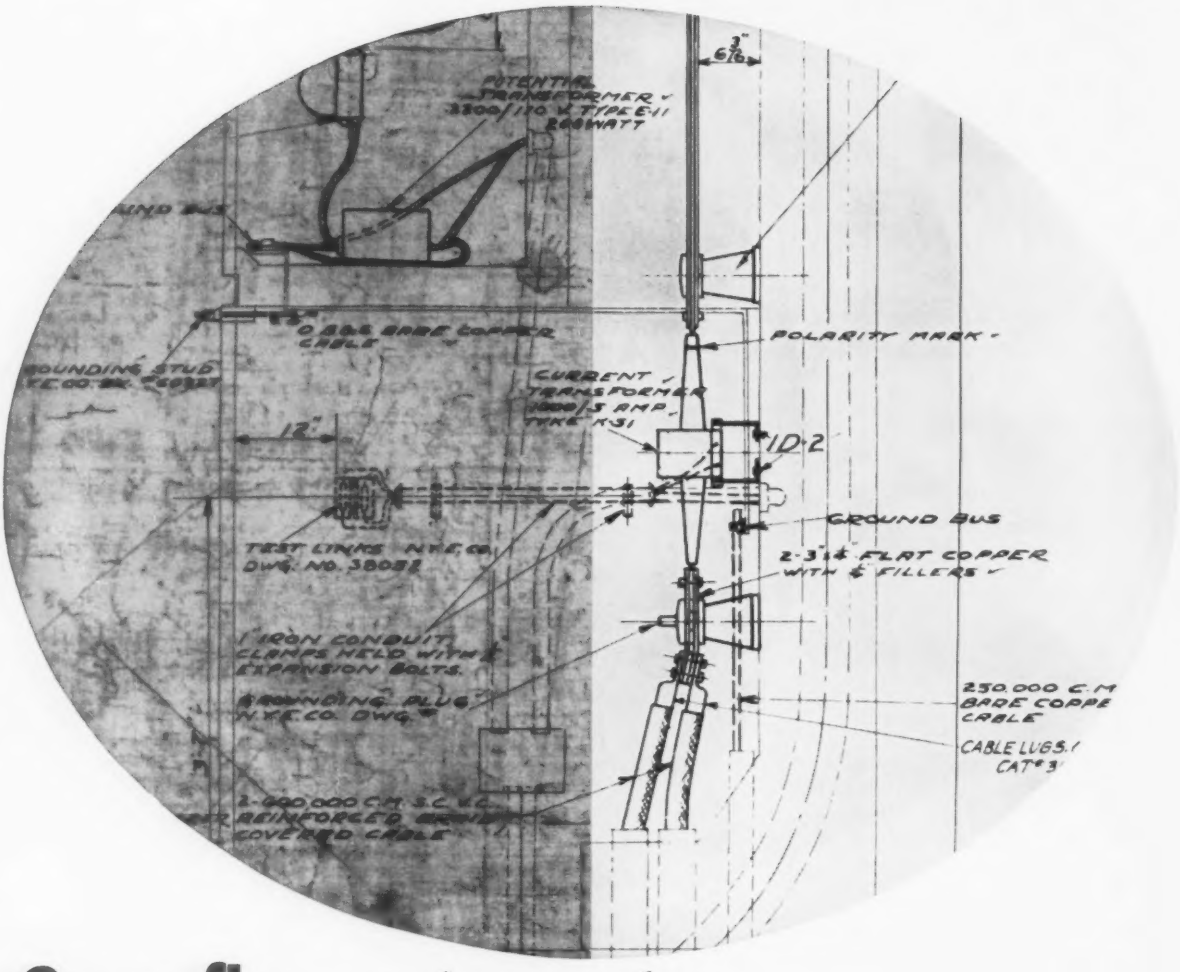
For further details, write for Bulletin 2400.

DE LAVAL *Steam Turbine Company*

Nottingham Way, Trenton 2, New Jersey

Please direct inquiries to advertiser, mentioning MACHINE DESIGN

DL-431



Cronaflex prints clean:

TRADEMARK

Eliminates kinks, smudges, creases from original drawing

Examine these two prints. The one on the left, on cloth, bears the same scars of age and wear as the old original drawing. The copy on the right, made from the same original, is on CRONAFLEX. See how CRONAFLEX has eliminated the kink marks, cleaned up the smudging—actually improved the drawing.

Corrections can be made right on your CRONAFLEX copies . . . in either pencil or ink. Even photographic lines can be removed, then corrected, *on either side of the film* because CRONAFLEX is double-matted.

Your drawings on CRONAFLEX are rugged. They can be used to make literally hundreds of copies on standard reproduction machines. Also, your CRONAFLEX copies will not smear or discolor with constant handling, like cloth does.

For more information on this new line, see your Du Pont Technical Representative, or write: E. I. du Pont de Nemours & Co. (Inc.), Photo Products Department, Wilmington 98, Delaware. In Canada: Du Pont Company of Canada (1956) Limited, Toronto.

This advertisement was prepared exclusively by Phototypography.

DU PONT

REG. U. S. PAT. OFF.

Better Things for Better Living . . . *through Chemistry*

Circle 434 on Page 19

Circle 435 on Page 19→

d'Arazien

Alcoa puts the metal where you want it

Before you read on, blink your eyes. In the time it took to do that, this man has produced an entire automotive grease gun body—complete with external ribs; solid end; smooth, seamless interior; and go-to-market external finish.

Sound too easy? No! We can make round, oval, square and irregular parts the same way. Finished parts—with the strength of forgings—with tolerances down to plus or minus 0.005"—with a smooth, corrosion-resistant finish of about 125 microinches. A clear case of putting the metal where *you* want it. The cost of tooling for impacts is surprisingly low, too. A good rule to remember is that virtually any closed end or tubular design should be considered as an Alcoa® Impact.

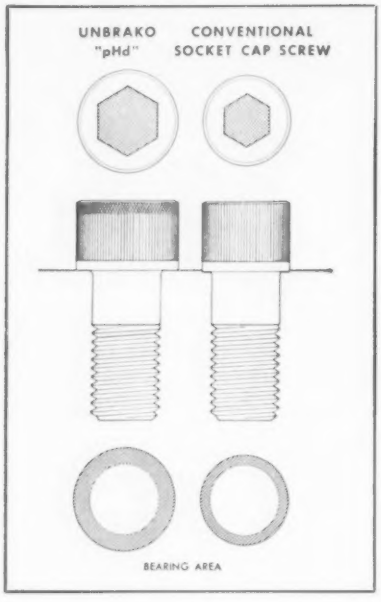
In impacts, as well as forgings, castings, extrusions and screw machine parts . . . Alcoa puts the metal where you want it. A call to Alcoa can mean fewer rejects or ingenious design solutions . . . less waste in production or a product that sells faster. Start now; write for Alcoa Up-to-Daters, a file of design tips on Alcoa Engineered Products. Aluminum Company of America, 1999 Alcoa Building, Pittsburgh 19, Pennsylvania.

ALCOA ALUMINUM

Alcoa puts the metal where you want it . . . in castings, forgings, extrusions, screw machine parts and impacts

ALCOA THEATRE
FINE ENTERTAINMENT
ALTERNATE MONDAY EVENINGS

Up to 233% more holding power with NEW UNBRAKO *pHd** socket cap screws



***pHd stands for "proper head design"—a factor in higher product reliability**

Enlarged head diameter, without change in head height, increases usable fastener strength as much as 134%, provides as much as 233% more holding power. The greater clamping force achieved with the new UNBRAKO pHd means longer fastener life under dynamic loads, offers the following advantages:

- Miniaturization. Space and weight-saving through use of smaller diameter or fewer screws. The 170,000-190,000 psi of these fasteners can be used to greater advantage.
- Reduction of fatigue failures. pHd allows consistently higher preloading, a major factor in lengthening the fatigue life of threaded fasteners.
- Fewer loosened threaded fasteners under shock or vibration.
- Eliminates washers under the heads of cap screws where they are used to increase the effective bearing area.
- Minimizes effect of oversized holes on the head-bearing area.

The head diameter, enlarged on 5/16, 7/16, 9/16‡, 5/8, 3/4, 7/8 and 1 in. sizes, also prevents the screw head from indenting the material being assembled—a fault that normally reduces, and sometimes completely loses, the vital preload or tensile stretch that keeps the screw tight and prevents fatigue failure. pHd also provides room for a bigger socket, which permits tightening to higher recommended preloads.

COMPARISON OF UNBRAKO pHd AND CONVENTIONAL DESIGN

Each size can now be utilized with equal reliability. The bearing stress is consistent from size to size in the new UNBRAKO pHd socket cap screws.

SCREW SIZE	HEAD DIAMETER (in.)		BEARING AREA (sq. in.)		LOAD TO INDENT IN CAST IRON (lb.)		% INCREASE USABLE STRENGTH	TIGHTENING TORQUE (lb.-in.)†	
	Old	pHd	Old	pHd	Old	pHd		Old	pHd
1/4	.375	.375	.041	.041	3,280	3,280	–	165	180
5/16	.438	.468	.047	.072	3,760	5,760	54	325	360
3/8	.562	.562	.102	.102	8,150	8,150	–	600	660
7/16	.625	.656	.116	.148	9,270	11,800	27	1,000	1,040
1/2	.750	.750	.188	.188	15,000	15,000	–	1,450	1,590
9/16‡	.812	.843	.209	.247	16,700	19,700	18	2,050	2,270
5/8	.875	.937	.203	.305	16,200	24,400	51	2,900	3,190
3/4	1.000	1.125	.223	.432	17,800	34,600	94	5,050	5,600
7/8	1.125	1.312	.254	.594	20,300	47,500	134	8,000	8,900
1	1.312	1.500	.364	.785	29,100	62,800	116	10,550	13,600

†Normal recommended seating torques for unplated screws, fine threads

‡Available as a special only (listed for dimensional data)

High Reliability

SPS research is continually developing fasteners with higher and higher standards of predictable performance. By installing SPS high reliability fasteners in your assemblies, you increase your overall product reliability.

"High Reliability" is a booklet just published by SPS. Write for your copy today.

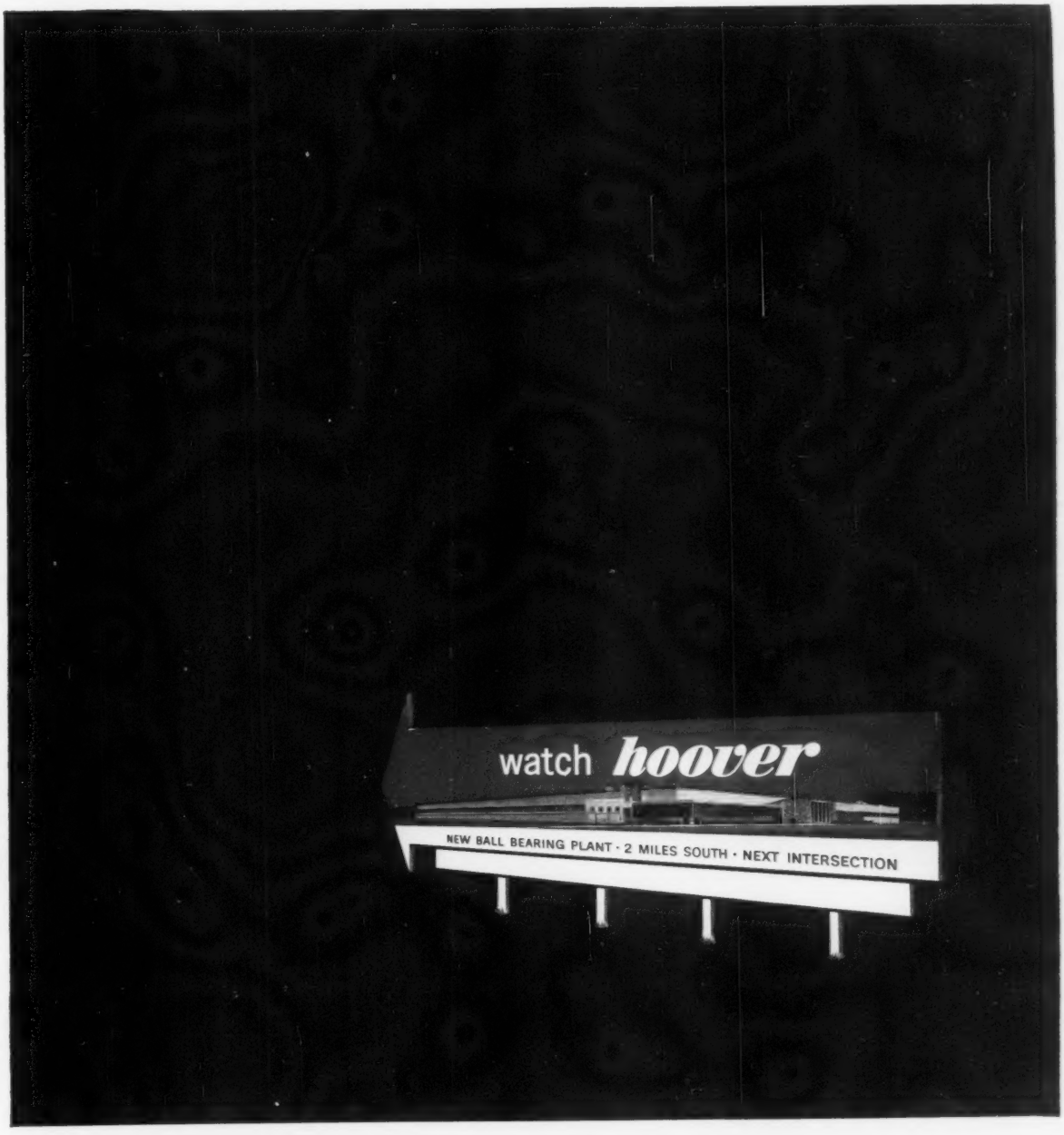
The new UNBRAKO pHd socket head cap screw is now available through all authorized industrial distributors at no increase in price. Specify UNBRAKO pHd when ordering. For technical data and specifications, send for Bulletin 2406. Unbrako Socket Screw Division, STANDARD PRESSED STEEL CO., Jenkintown 18, Pa.

We also manufacture precision titanium fasteners / write for free booklet

SPS Jenkintown • Pennsylvania

Standard Pressed Steel Co. • The Cleveland Cap Screw Co. • Columbia Steel Equipment Co. • National Machine Products Co. • Nutt-Shel Co. • SPS Western • Standco Canada Ltd. • Unbrako Socket Screw Co., Ltd.

Circle 436 on Page 19



GOOD SIGN FOR BEARING BUYERS! On Michigan's famed Willow Run Expressway, signs like the one above point to the newly completed Hoover plant. Here, new equipment and modern techniques are skillfully utilized to produce increased quantities and additional types of America's *Quality* Balls and Bearings. Hoover has made these major improvements to provide better service for present customers . . . to serve more and more new customers. You are invited to write for complete information about Hoover products. Watch Hoover for future announcements of interest to bearing buyers.

hoover

BALL AND BEARING COMPANY

5400 South State Road, Ann Arbor, Michigan

Los Angeles Sales Office and Warehouse: 2020 South Figueroa, Los Angeles 7, California

Circle 437 on Page 19

Weldability—Welding is the only technique that we can use to join two pieces of metal so that they act as a single piece of metal.

Not *all* metals. Steel stands alone as the most weldable of all practical metals. Not *all* steels, but most of them can be welded without any sacrifice of strength or elastic behavior. More than that, steel can usually be welded without special precautions, without critical timing procedures, without excessive heat input, without elaborate and corrosive fluxes, without color change in the base metal, and with little danger of cracking. Welding engineers deserve most of the credit for the fact that steel can be welded so easily. With their help, steel producers have made many important break-throughs.

Before the 1930's, carbon and manganese were the main strength-producing elements in steel. Designers wanted stronger steels so they could build lighter structures—and they wanted to *weld* these steels because there is no lighter fastening system. But as the carbon content was raised to strengthen the steels, the weldability decreased and designers were handicapped because they had to fasten "light-weight" high carbon steels with heavy rivet and gusset-plate assemblies.

In 1933 United States Steel introduced the first *low carbon*, high-strength, low-alloy steel—USS COR-TEN Steel—and later USS TRI-TEN Steel. Both steels achieved 50,000 psi minimum yield strength with alloying elements other than carbon, and could be welded with normal procedures. The world of alloy steels was brightened, too, with the introduction a few years ago of USS "T-1" Steel, a constructional alloy steel combining tremendous strength (100,000 psi min. yield strength), toughness *and* weldability without requiring preheating or stress relief.

No matter what combination of properties you desire in a steel, there is a weldable steel that will do the job. In fact, there is theoretically *one* best steel for any application, and it can be selected from our family of Steels for Design: Carbon, High Strength, Alloy and Stainless. If you could use help in finding it, check United States Steel, 525 William Penn Place, Pittsburgh 30, Pennsylvania.

United States Steel Corporation • American Steel & Wire • Columbia-Geneva Steel • National Tube
Tennessee Coal & Iron • United States Steel Supply • United States Steel Export Company

USS United States Steel

Please direct inquiries to advertiser, mentioning MACHINE DESIGN

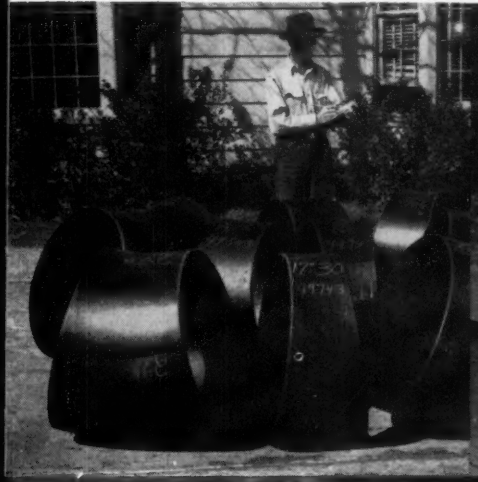
STEELS FOR DESIGN

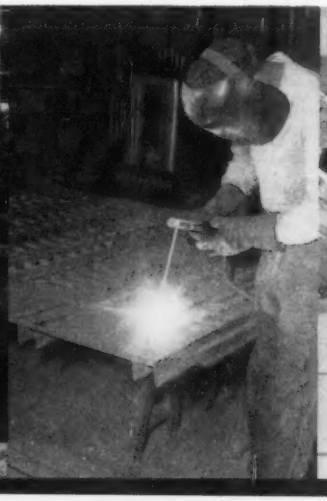
Lower Left—Problem: Design butt-weld fittings for high-pressure oil and gas lines. Solution: Designer used USS TRI-TEN Steel, a high-strength, low-alloy steel particularly noted for its weldability. Pay-off: Fittings made lighter due to thinner plates; welding was fast and easy; less weld metal was needed; and the weld was as strong as the parent metal.

Lower Middle—Problem: Build a bedplate for a printing press requiring 534 welds. Solution: Builder used USS "T-1" Constructional Alloy Steel. Pay-off: Tremendous strength and toughness of "T-1" withstands thunderous impact from high-speed printing rollers and cutting knives—*and not one weld has failed.*

Lower Right—Problem: Convert a concrete reservoir into a storage area for 2,000,000 gallons of ammonium nitrate. Solution: Reservoir was lined with corrosion-resistant USS Stainless Steel sheets. Pay-off: Quick, easy installation because the Stainless sheets were welded right on the job—3½ *miles* of lap seams were welded and only two tiny imperfections were found when the welds were vacuum tested.

USS, "T-1," Cor-Ten and Tri-Ten are registered trademarks





"PONY POWER" MOTORS

that give stamina to your products

Lamb Electric ***fractional*** horsepower motors, like the small horses of the famed western-pioneer-day Pony Express, are developed for *stamina.*

Their dependability, and efficiency (optimum weight-size-horsepower ratio) are qualities that result from proper design and careful manufacture by personnel with many years of experience in the small motor field.

May we demonstrate how Lamb Electric Motors can bring these advantages—and also perhaps lower costs—to *your* products?

THE LAMB ELECTRIC COMPANY • KENT, OHIO

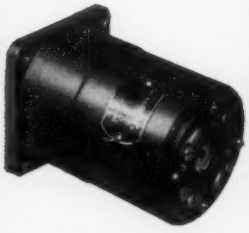
A Division of American Machine and Metals, Inc.

In Canada: Lamb Electric — Division of Sangamo Company Ltd. — Leaside, Ontario

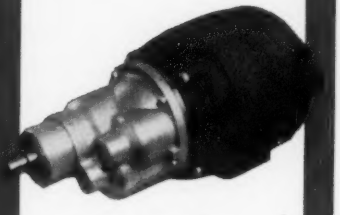
Lamb Electric

SPECIAL APPLICATION FRACTIONAL HORSEPOWER **MOTORS**

A rugged high-torque, high-speed motor.



Radar voltage regulator gear motor.

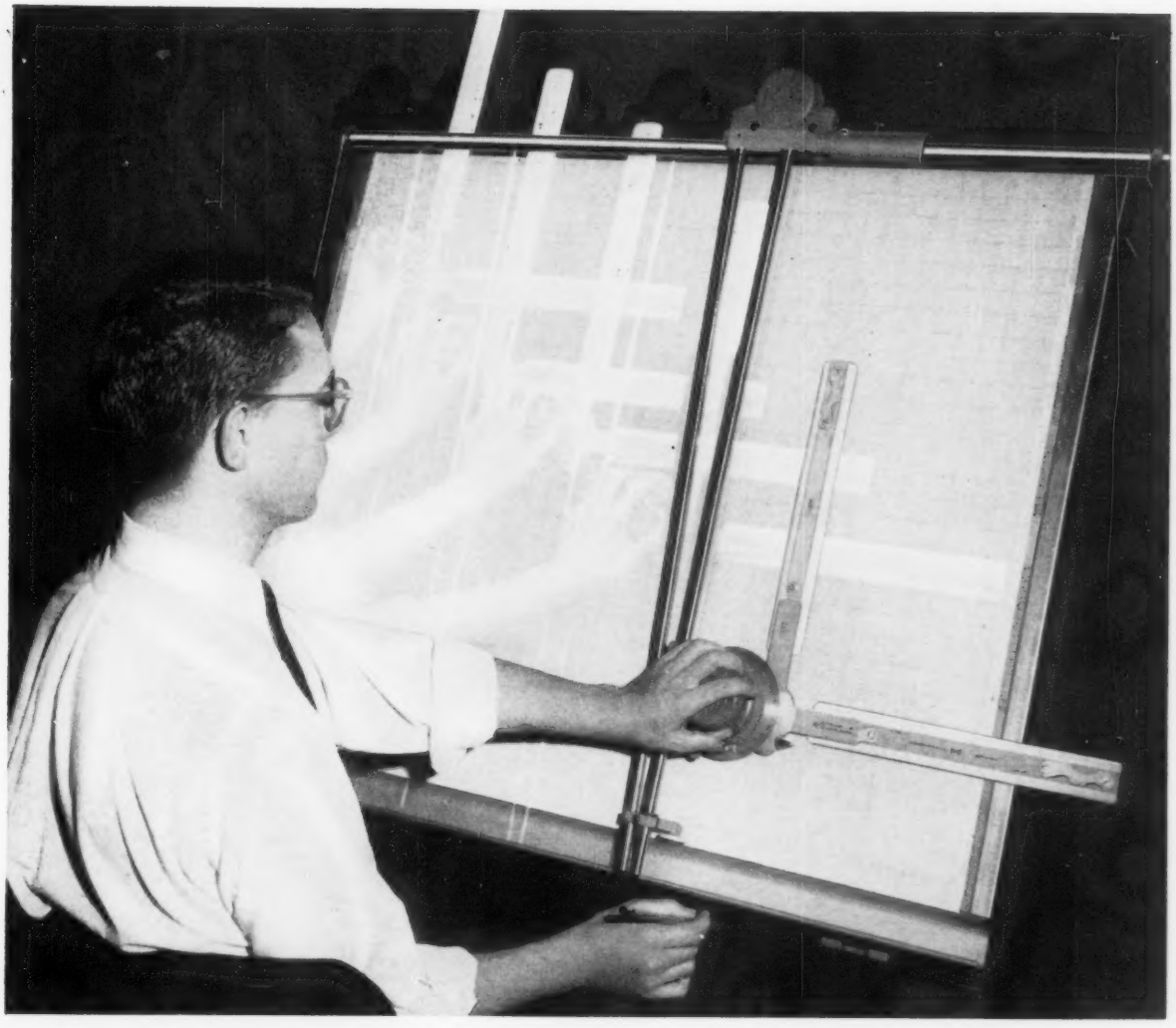


Motor with efficient spur gear speed reducer.

Motor for high-speed grinder.

If you are interested in any of the above motors write and we shall be glad to send full information.

Circle 440 on Page 19



...for as little as $148.50

New K&E Paragon Auto-Flow gives you faster, easier drafting 5 ways...

The first time you use it, you'll know that K&E's light-weight Paragon® *Auto-Flow*™ Drafting Machine is a truly great advance in working ease and range. Here are 5 *specific* reasons why.

It's more versatile. Stays in perfect balance at any board angle, from vertical to horizontal. No adjustments needed, except a simple turn of a tension spring wheel for angles below 15 degrees.

It's more compact. The balance is built right into the machine itself. There's no need for counterbalances that project over the top of the board.

It's better made. Glides smoothly and easily on finely-ground, stainless steel rails with K&E precision and quality in every detail.

It's more adaptable. You get a full sweep of every size of board.

It's far easier to use. The scales move smoothly, at the slightest touch. Long lines up or across can be drawn in a single motion. Scales lock in place to eliminate "drift". Greater rigidity produces truer lines.

The 30" by 40" *Auto-Flow* costs only $148.50 . . . the 36" by 60" only $160. All standard sizes; left-hand models available. Mail coupon for details. 1265

KEUFFEL & ESSER CO. Dept. MD-10, Hoboken, N. J.

☐ Please send information on the new K&E Paragon *Auto-Flow*. ☐ Please arrange a demonstration for me.

Name & Title: _____

Company & Address: _____

_____

Circle 441 on Page 19

"Can you afford NOT to have the best possible single-phase and polyphase motor protection?"

. . . with KLIXON Protectors You Get Maximum Motor Overload Performance with Minimum Burnouts and Costly Down Time

There are several ways to protect your three-phase motors against destructive overloading — but only KLIXON built-in Protectors provide the following:

- **Elimination of motor burnouts**
- **Maximum output of motor under any overload**
- **Minimum motor repair and replacement**
- **Simplified motor controls**
- **Least production down time**

In a KLIXON protected motor you get a tested combination of protector and motor — either single-phase or three-phase — which has been installed by the motor manufacturer.

When the motor and the protector are matched you know you are getting the best possible protection against overheated motors caused by:

- **Prolonged overloads**
- **Failure to start**
- **Stalling**
- **Lack of ventilation**
- **Increase in ambient temperatures**
- **Plugging or reversing duty**
- **Unbalanced voltage**

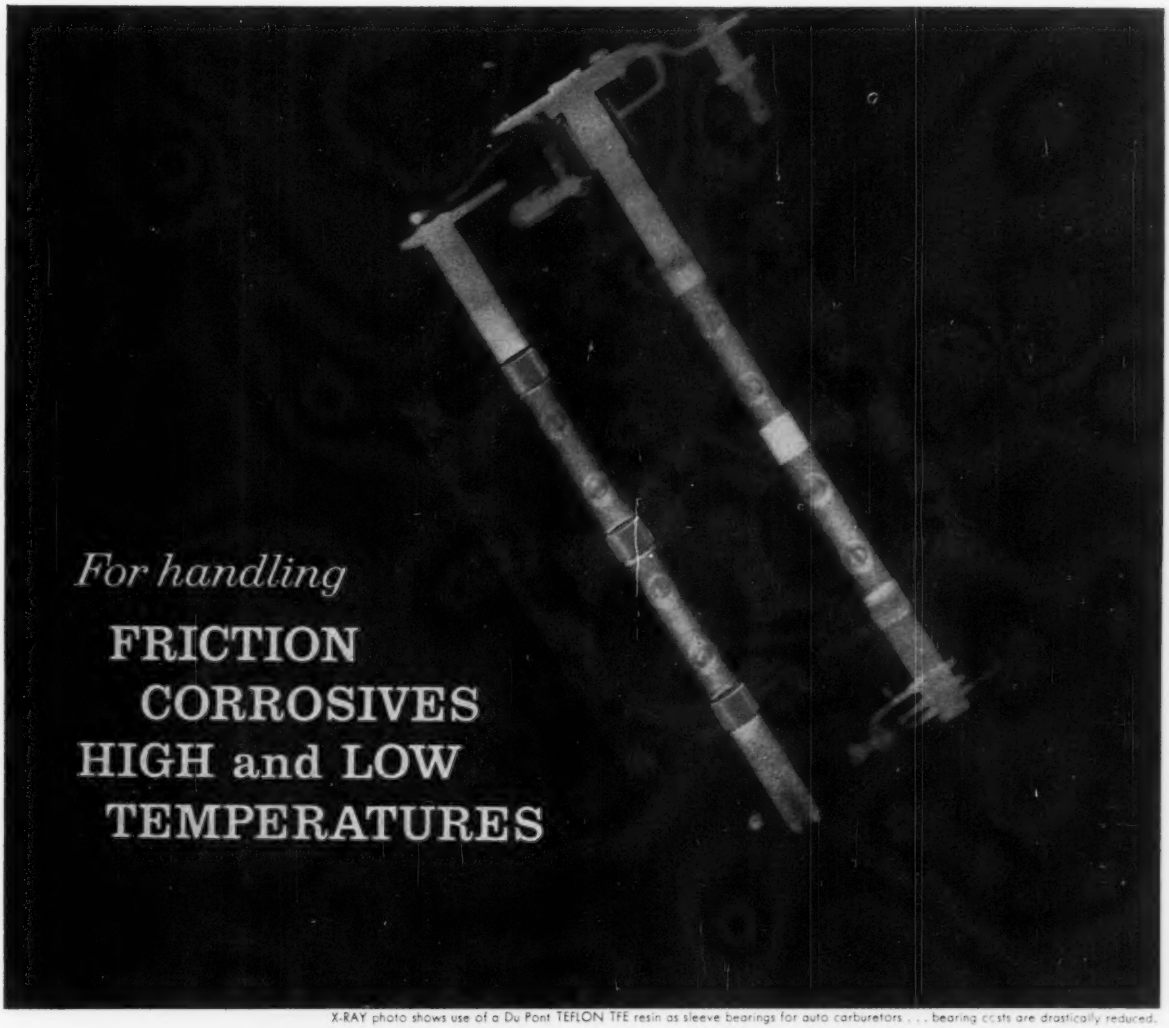
Be sure you get everything you expect from motor protection — specify KLIXON protection when you order motors. For full information, check with your motor supplier's district office, or write us for a copy of our new bulletin PR-1243 on KLIXON three-phase motor protection.

METALS & CONTROLS CORPORATION

Spencer Division 3210 Forest Street, Attleboro. Mass.

KLIXON®

Circle 442 on Page 19



X-RAY photo shows use of a Du Pont TEFLON TFE resin as sleeve bearings for auto carburetors . . . bearing costs are drastically reduced.

Here's why bearings of TFE-fluorocarbon resins may be your solution

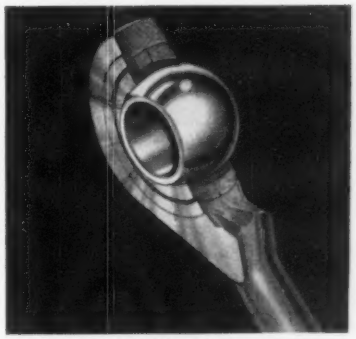
Bearings of TFE-fluorocarbon resins are "self-lubricating". Even the best lubricants used on metal rarely provide a coefficient of friction as low as 0.04, which is readily attained with TFE resins at low velocities. Moreover, TFE resins are among the most chemically inert materials known to science. They are rated for continuous use at temperatures from −450°F. to 500°F.

THAT'S WHY: You can use *dry bearings* of TFE resins where lubrication is difficult or even impossible. They perform unharmed in contact with hot, corrosive liquids . . . keep products free of contamination by eliminating oil and grease. In liquid oxygen service (-321°F.), bearings of TFE resins offer the same low friction they do at room temperatures.

In use, the bearings coat revolving shafts with a molecular film of the TFE resin. Thus, any friction is that of the resin against itself. Bearings of TFE resins can be tailored for high loads, high velocities or high wear-resistance by the use of reinforced constructions.

Discover how you can improve your products and processes with bearings of Du Pont TFE-fluorocarbon resins. For product and design information see your local supplier. Look for him under "Plastics—Du Pont" in the Yellow Pages or write to: **E. I. du Pont de Nemours & Co. (Inc.), Room MD2524, Nemours Building, Wilmington 98, Delaware.**

In Canada: Du Pont Company of Canada (1956) Limited, P.O. Box 660, Montreal, Quebec.



• A heavy duty TFE resin construction replaced a super-alloy in rod-ends of aircraft controls. Lined sockets withstand operating loads as high as 60,000 psi without lubrication. Break-away and running friction are less than half that of a greased bearing.

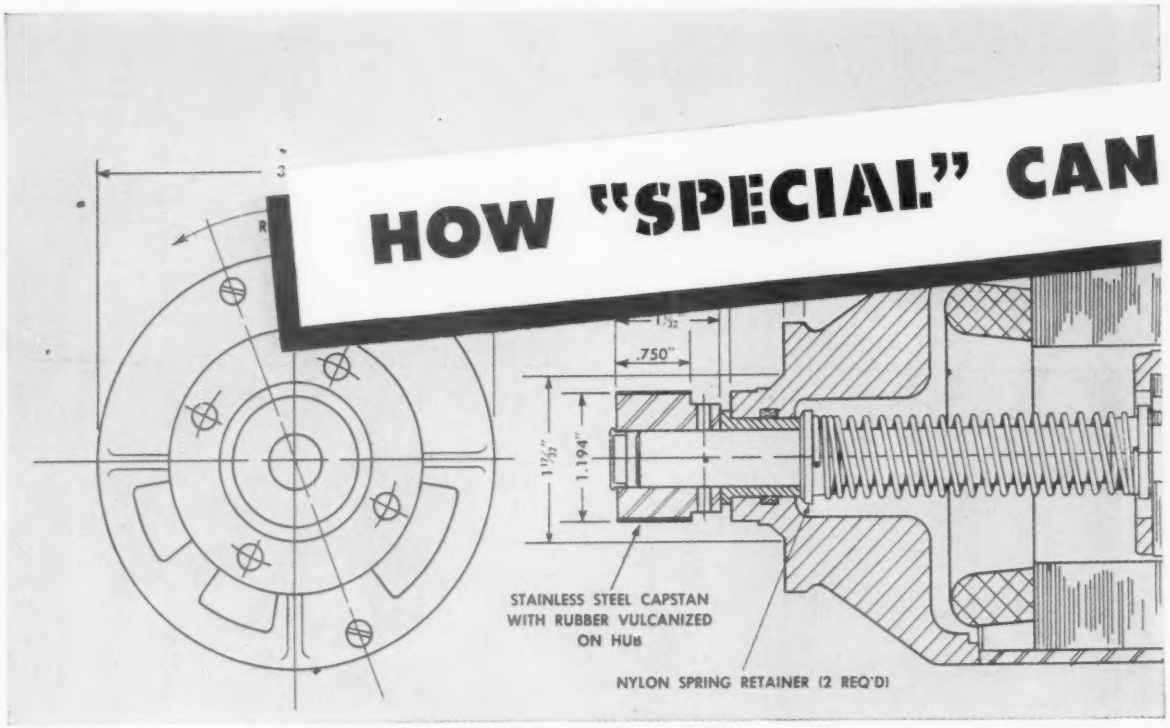
DU PONT
REG. U.S. PAT. OFF.

TEFLON®
TFE-FLUOROCARBON RESINS

BETTER THINGS FOR BETTER LIVING . . . THROUGH CHEMISTRY

TEFLON is Du Pont's registered trademark for its fluorocarbon resins, including the TFE (tetrafluoroethylene) resins discussed herein.

Circle 443 on Page 19



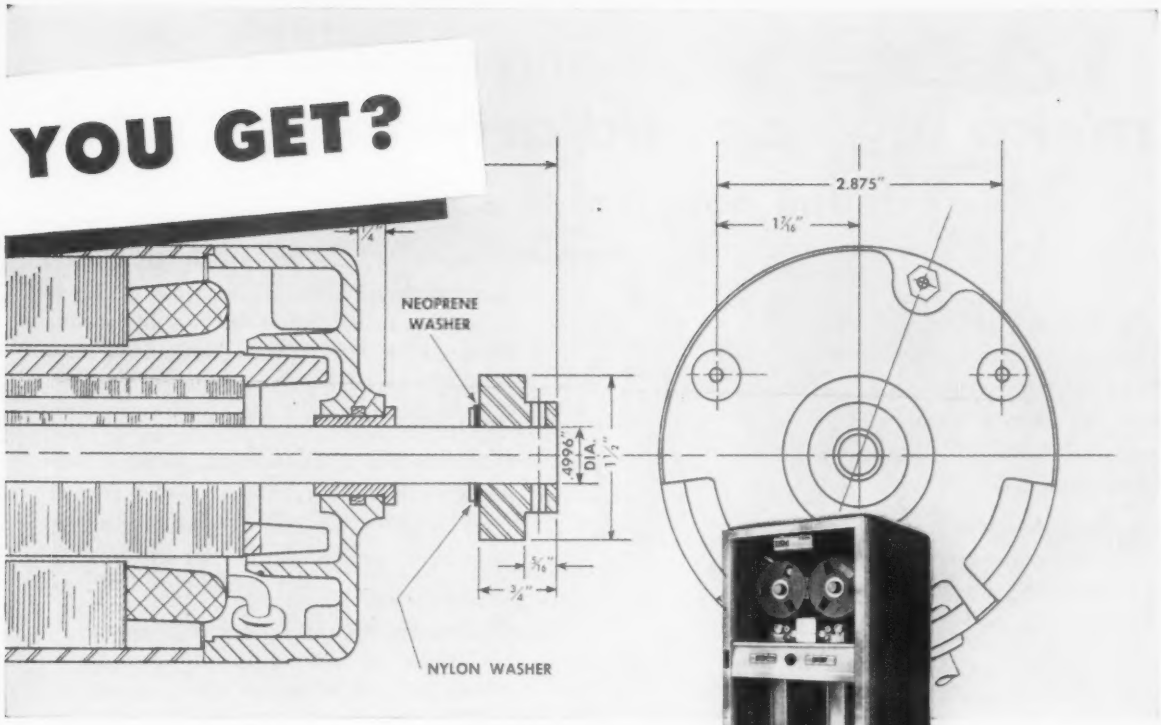
SPECIAL ROBBINS capstan motors function

SPECIFICATIONS

Reluctance synchronous motor, 1/20 HP, 60 cycle, 3 phase, 208 volts ± 8%, 1200 RPM . . . Rotor dynamically balanced to commercial specifications . . . Shaft is shown in position when motor is stopped . . . When motor is running at synchronous speed, a minimum axial force of 350 grams is required with spring in place before displacement occurs . . . When rotor is in its retracted position and power is applied, the minimum axial force developed with spring in place is 100 grams . . . When power is cut off, the spring retracts the rotor with minimum 50 gram force while rotor is rotating.

Robbins & Myers builds motors from 1/200 to 200 horsepower

YOU GET?



& MYERS

accomplish unique in IBM'S 727 magnetic tape unit!

SHAFT ROTATES AND MOVES AXIALLY

Two of these special R&M motors are used in each of IBM's 727 Magnetic Tape Units. They answer IBM's need for a tape unit drive motor with a retractable capstan. The rotating shaft moves axially when the motor is started or stopped.

A spring holds the rotor, shaft and capstan in retracted position when the motor is stopped. When started, as the motor attains synchronous speed, axial force created as the rotor centers itself in the field becomes sufficient to overcome spring resistance. The capstan moves into engaged position and sends the tape reels rolling. Another capstan on the opposite end of the shaft (at right in drawing) actuates two microswitches as the rotor returns to retracted position when motor is stopped.

Four additional R&M fractional horsepower motors perform other high-speed power tasks within the tape units —driving reels, rewinding, unloading tape and retracting guide mechanisms.

R&M motors meet strict IBM engineering requirements: precise adaptability to special functions, capacity for lightning starts and stops, and absolute dependability. R&M can also design and build motors of highest quality designed to your exact specifications. For reliable fractional power, contact Robbins & Myers!

R&M

ROBBINS & MYERS, INC.

SPRINGFIELD, OHIO / BRANTFORD, ONTARIO

MOTORS FANS HOISTS MOYNO PUMPS (INDUSTRIAL) PROPELLAIR FANS

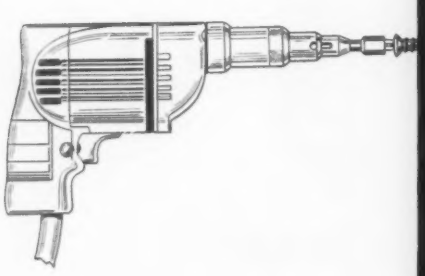
Circle 444 on Page 19

Continental sets quality standards to **make high-speed driving pay off** its full potential in savings

Are you "collecting" the savings you rightfully expect from the use of automatic screw driving machines and other power driving equipment? Most of the potential savings can be wasted when fastener faults cause frequent downtime on the assembly line.

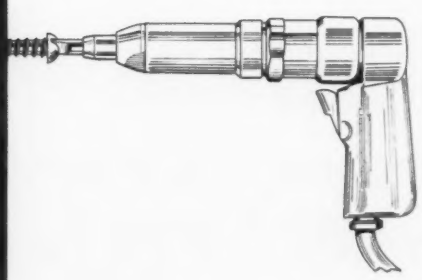
That is why Continental quality-control standards are matched to the most exacting demands of high-speed driving equipment. Special tests and trial runs are used to spot any defects that might pass undetected in ordinary inspection. No screws that fail to meet Continental's close tolerances get by. You get dependable uniformity in every detail, and avoid slow-downs.

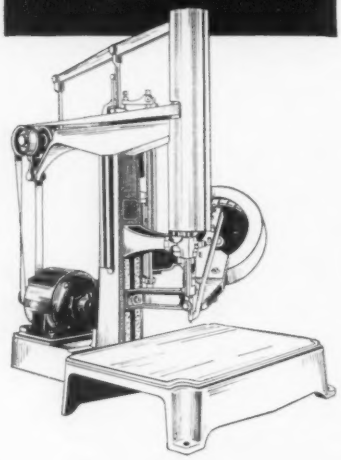
Next time you order fasteners, specify Continental HOLTITE. You'll see why Continental users "collect"—day after day—the *full savings* planned in assembly. For prompt service, write or phone: Continental Screw Co., 461 Mt. Pleasant St., New Bedford, Mass.



Here's where you win or lose on fastener costs.

Keep assemblies trouble-free.





Test runs duplicate assembly line conditions

Automatic screw driving machines of the types in current use are set up in the Continental quality-control laboratory as required for test runs under job conditions. With these and many other tests, Continental assures you of fastener quality and uniformity matched to the toughest high-speed driving demands.

Are you missing savings you could be making?

Find out how Continental specialized cost-saving experience can help you. At your request, a Continental Assembly Specialist will survey your operations, and make detailed recommendations for maximum cost reduction. This advice is unbiased, since HOLTITE Fasteners include all types of threaded fasteners.

MEMBER
SCREW RESEARCH
ASSOCIATION

CONTINENTAL
HOLTITE FASTENERS

HOLTITE PHILLIPS AND SLOTTED HEAD
WOOD • MACHINE • TAPPING • THREAD-FORMING • SEMS • NYLOK
HY-PRO PHILLIPS INSERT BITS AND HOLDERS

New Design Versatility with RŌTAC

Compact, powerful Rōtac Torque Actuators have a wide range of applications

RŌTAC Rotary Torque Actuators consist of a cylindrical chamber containing a stationary barrier or shoe, and a central shaft with a fixed vane. With fluid or pneumatic pressure applied to either side of the vane, rotary movement in the opposite direction is obtained; power can be doubled by using double-vane shafts. One moving part insures long life and low maintenance.

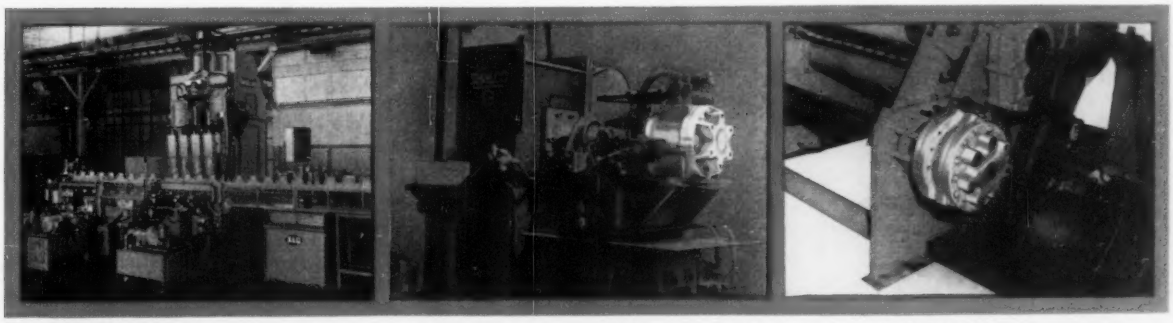
Rōtac Actuators can be mounted vertically, horizontally or at any angle, with the housing held stationary or with the body rotating around the shaft.

Wherever you need motion—powerful, easily controlled rotary action in compact form—Rōtac Actuators simplify design and provide unlimited possibilities for use in various applications.

FREE DESIGN DATA BOOK—20 PAGES

Contains everything you'll want to know about RŌTAC—How it works • Control • Typical applications and special uses • Installation details • Dimensions • Torque ratings • Helpful ideas for using RŌTAC Actuators in your operations.

MOBILE EQUIPMENT—A compact RŌTAC Torque Actuator swings this truck-mounted crane boom in a 280° travel arc; it's controlled through a 4-way valve.



MACHINE TOOLS—Automation machine for boring and grooving piston wrist pin holes uses RŌTAC Torque Actuator for positioning the orienting arbors.

FOUNDRY MACHINERY—Ex-Cell-O Model HN-66-1V RŌTAC Actuators supply the motive power for turnover of the core-box on this semi-automatic shell core blower.

PAPER MACHINERY—This collector roll is actuated by a standard model RŌTAC Actuator which unloads material after a slitting operation is performed.

EX-CELL-O CORPORATION

58-15

GREENVILLE PLANT, GREENVILLE, OHIO

XLO EX-CELL-O FOR PRECISION

EX-CELL-O PRECISION PRODUCTS INCLUDE:
- MACHINE TOOLS • GRINDING AND BORING SPINDLES
- CUTTING TOOLS • RAILROAD PINS AND BUSHINGS
- DRILL JIG BUSHINGS
- AIRCRAFT AND MISCELLANEOUS PRODUCTION PARTS
- TORQUE ACTUATORS • DAIRY EQUIPMENT

Circle 446 on Page 19

RB&W FASTENER BRIEFS

RUSSELL, BURDSALL & WARD BOLT AND NUT COMPANY

Technical-ities

By John S. Davey

Selecting the right grade of nuts

"Workhorse" among nuts is the standard "FINISHED" series. It gives good seating area; sufficient height to sustain high thread tension; enough wall thickness to control elastic nut dilation under load.

"HEAVY" nuts are wider than "Finished" nuts in *all* sizes by only ⅛" across flats. Thus, their value diminishes as size increases. Most effective in ½" to 1½" range, they satisfy applications involving excessive clearance holes, unusual loads, and certain boiler codes.

MATERIALS? The regular carbon nut steel (non heat treated). It makes nuts strong enough to pull bolts beyond yield point, lets threads distribute load to avoid stripping.

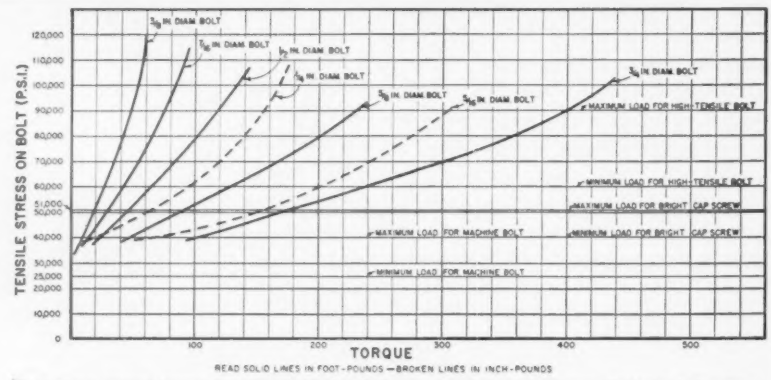
NUTS WITH "SPECIAL" FUNCTION

JAM NUTS are made for position locking. Use of two together forms a superior and economical locking device. When used to lock a regular nut, jam nut should be adjacent to work surface. Otherwise, the jam nut takes the load – a job it wasn't designed for.

Use a 2H NUT where high temperatures call for stability.

HIGH NUTS are used for shackle, U and tractor pad bolts. They're furnished only in fine threads, therefore, and hardened. More to be recommended are *coarse thread* finished nuts.

Tightening up fasteners tightens down on costs


TENSILE STRESS ON BOLT (P.S.I.)
TORQUE
READ SOLID LINES IN FOOT-POUNDS — BROKEN LINES IN INCH-POUNDS
⅜ IN. DIAM. BOLT
⅝ IN. DIAM. BOLT
½ IN. DIAM. BOLT
⅝ IN. DIAM. BOLT
¾ IN. DIAM. BOLT
¾ IN. DIAM. BOLT
¾ IN. DIAM. BOLT
MAXIMUM LOAD FOR HIGH-TENSILE BOLT
MINIMUM LOAD FOR HIGH-TENSILE BOLT
MAXIMUM LOAD FOR BRIGHT CAP SCREW
MINIMUM LOAD FOR BRIGHT CAP SCREW
MAXIMUM LOAD FOR MACHINE BOLT
MINIMUM LOAD FOR MACHINE BOLT

These curves suggest torques for proper tightening of three grades of standard fasteners. Tightening to the upper limits delivers more of the holding power paid for, and assures stronger joints. Dropping below minimum values wastes fastener strength, invites loosening and failures. These curves are reproduced in RB&W Booklet DC-1.

It pays to go the limit in tightening bolts. Not only is it more economical, but safer too. For strength of a rigid connection depends on *residual tension* rather than on how strong the bolts are. Applying this fact can help avoid cost penalty.

EXAMPLE:

Blueprint specifies alloy bolts with strength of 145,000 psi. But assembly specification calls for tightening to what has been found an adequate pre-loading . . . only 30,000 psi. This wastes the fastener's capacity. It provides no more joint-strength than supplied by a *far more economical* RB&W bright cap screw tightened to same pre-load. It would be better to switch to the lower grade, or reduce size of the premium grade fastener.

REDUCING SIZE ALSO SAVES

A fastener's holding power is the same as its pre-load, or residual tension. So long as it permits tightening to the required pre-loading, the bolt can be small as possible.

EXAMPLE:

Design requires fasteners with safe load capacity of 20,000 lbs. Bright cap screws of ¾" size will do it; but so will ⅝" RB&W High Strength Bolts – *at less cost*. Actually, for the same holding power as in $1.00 worth of high tensile fasteners, $1.50 worth of bright cap screws are required.

PRODUCTION BENEFITS

Along with direct savings, smaller bolts mean smaller holes to drill or tap. Smaller holes often allow reduction in size of fastened members.

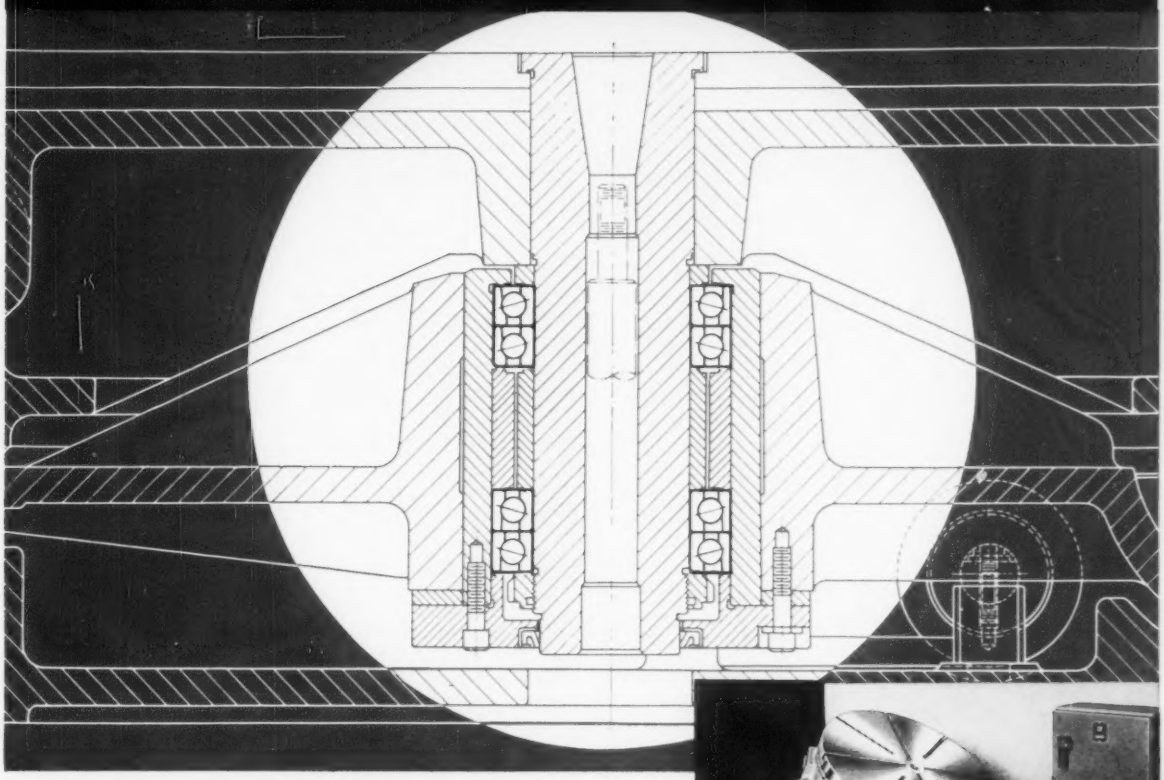
Talk to an RB&W fastener expert at the design stage of your product. He can help you cut costs without cutting joint strength.

Meanwhile, send for helpful booklet DC-1. Russell, Burdsall & Ward Bolt and Nut Company, Port Chester, New York.

Plants at: Port Chester, N.Y.; Coraopolis, Pa.; Rock Falls, Ill.; Los Angeles, Calif. Additional sales offices at: Ardmore (Phila.), Pa.; Pittsburgh; Detroit; Chicago; Dallas; San Francisco.

Circle 447 on Page 19

1½-ton rotary table held accurate to seconds of arc!



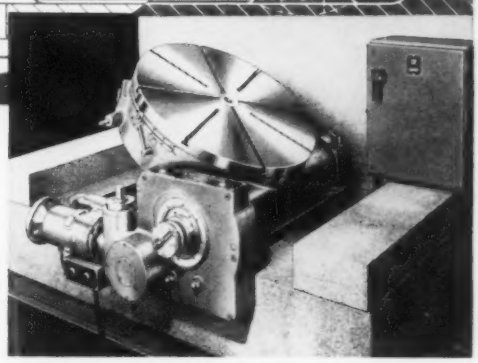
PRATT & WHITNEY
equips for precision with
FAFNIR BALL BEARINGS

The extreme accuracy designed into Pratt & Whitney's 36" Tilting Rotary Table puts a heavy premium on bearing performance. For the critical central pivot application, Fafnir super-precision ball bearings are specified.

Here are bearings with the capacity and rigidity to hold a ton-and-a-half table at *seconds of arc* accuracy — and maintain this precision under large-job work loads.

It takes plenty of bearing to deliver performance like that! Yet the application is typical of many in Fafnir's files. Fafnir's "experience in precision" can help *you* solve a bearing problem. Write The Fafnir Bearing Company, New Britain, Connecticut.

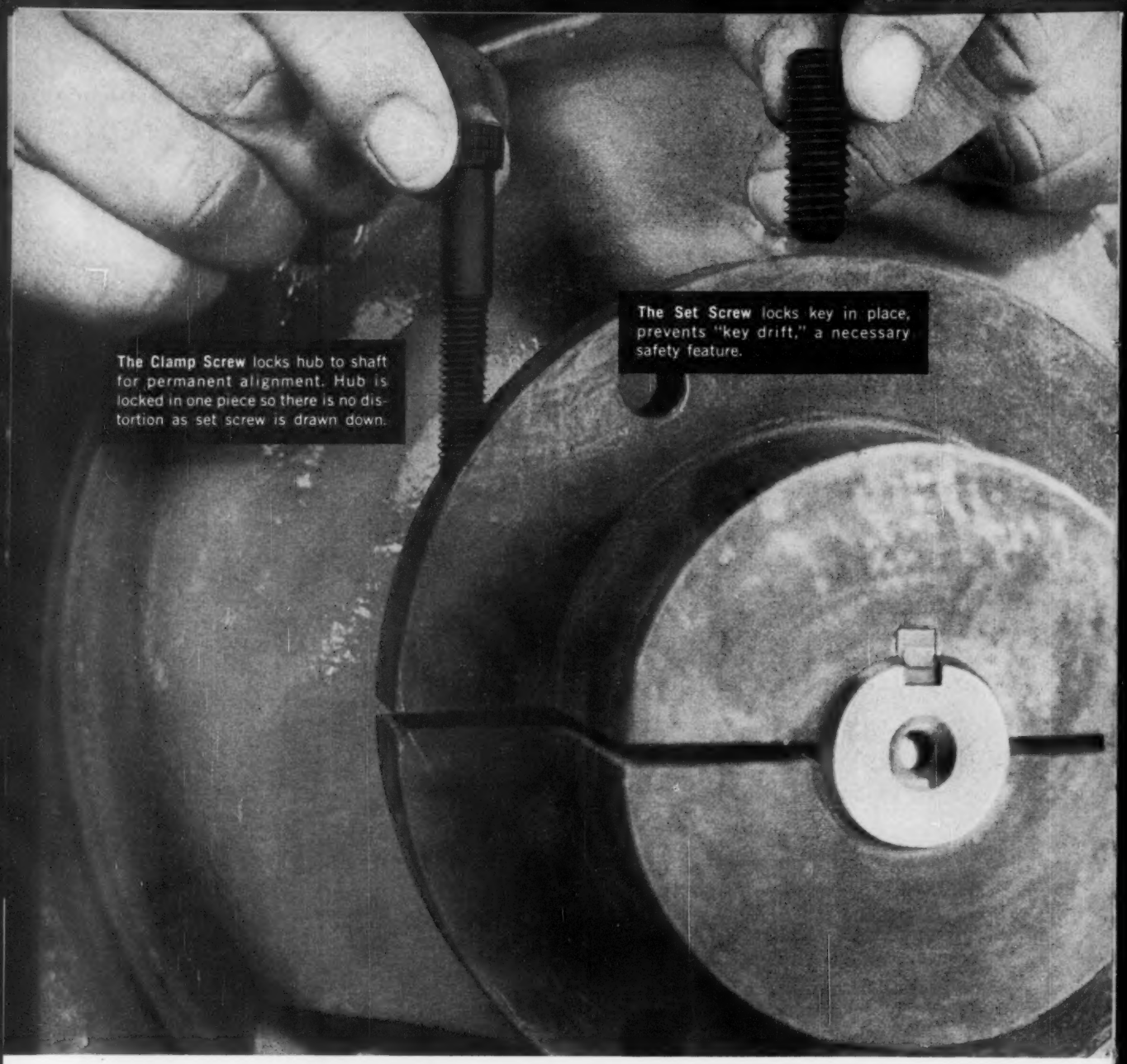
FAFNIR
BALL BEARINGS
MOST COMPLETE LINE IN AMERICA



Pratt & Whitney 36" Precision Tilting Rotary Table is designed for large jobs requiring precise circular spacing and angular positioning. It is completely powered . . . makes possible several machining or inspection operations with a single setup . . . permits direct rotary vernier readings to two seconds of arc over a 360° range and tilting vernier readings to one minute of arc over a 90° range, with a sine bar arrangement for setting table tilt accurately to seconds.

Fafnir Super-Precision Ball Bearings, counterbore construction, support the central pivot of the table component in Pratt & Whitney's 36" Tilting Rotary Table. Mounted in tandem duplex pairs, they provide the exceptional rigidity necessary for this precision application.

Circle 448 on Page 19


The Clamp Screw locks hub to shaft for permanent alignment. Hub is locked in one piece so there is no distortion as set screw is drawn down.
The Set Screw locks key in place, prevents "key drift," a necessary safety feature.

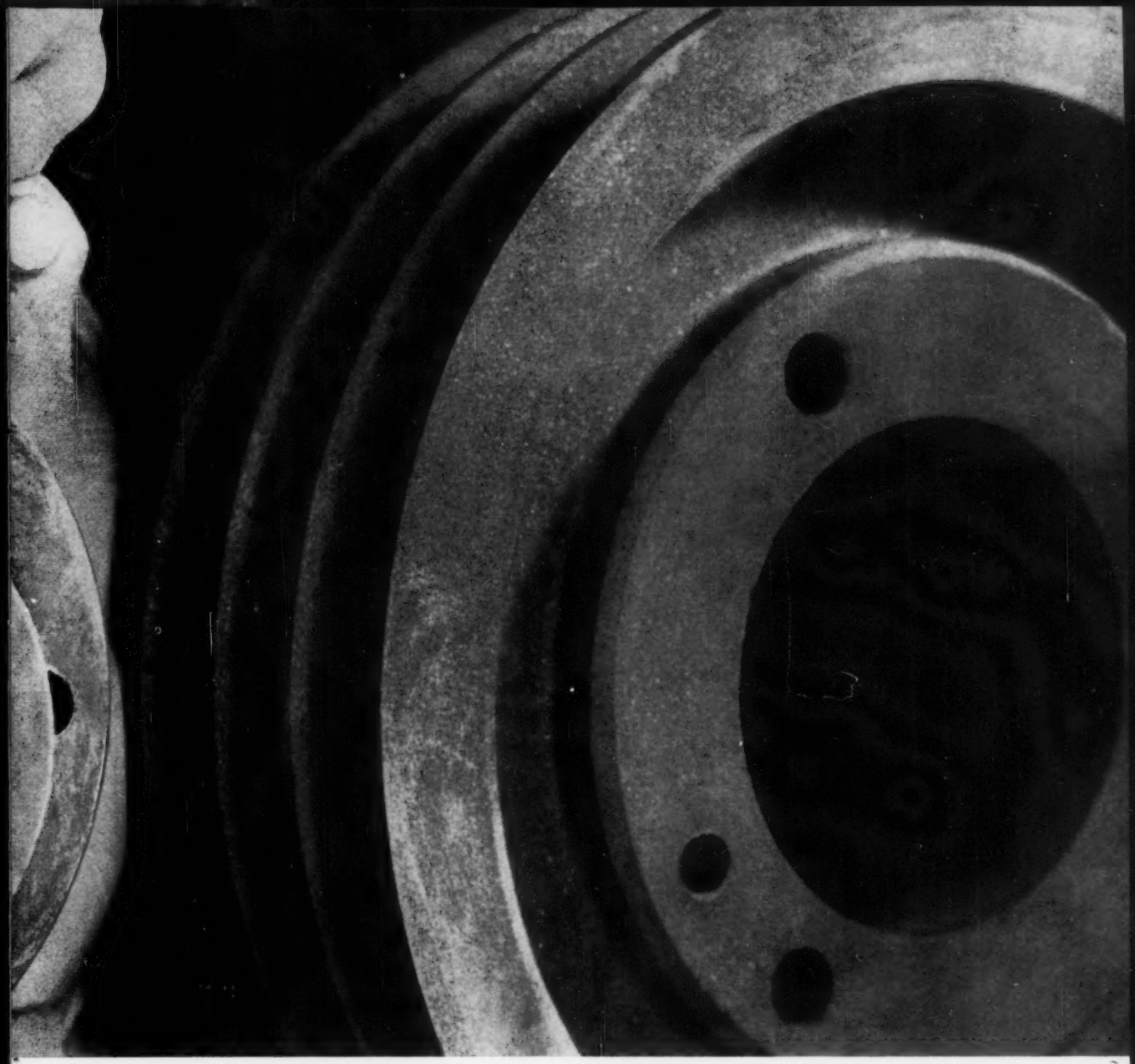
In Worthington QD Sheaves these extra

2 SCREWS MAKE

Exclusive features of Worthington QD Sheaves...

EASY ON! Two-piece design lets you install the sheave *one part at a time*. No heavy rim and hub combination to inch into place; the tapered hub slides easily on the shaft, is locked by the clamp screw for permanent alignment. The set screw locks key. Then the sheave rim slides easily into position on the taper-seat of hub because the large end of taper in sheave starts engagement with small end of taper on hub. Heavy hex-head bolts complete the assembly.

EASY OFF! Remove the big pull-up bolts and use two as jack bolts for easy rim removal. To change speed it's simple to mount a larger or smaller sheave on the hub which, because of clamp screw, remains aligned on shaft. You can install or remove one part at a time.



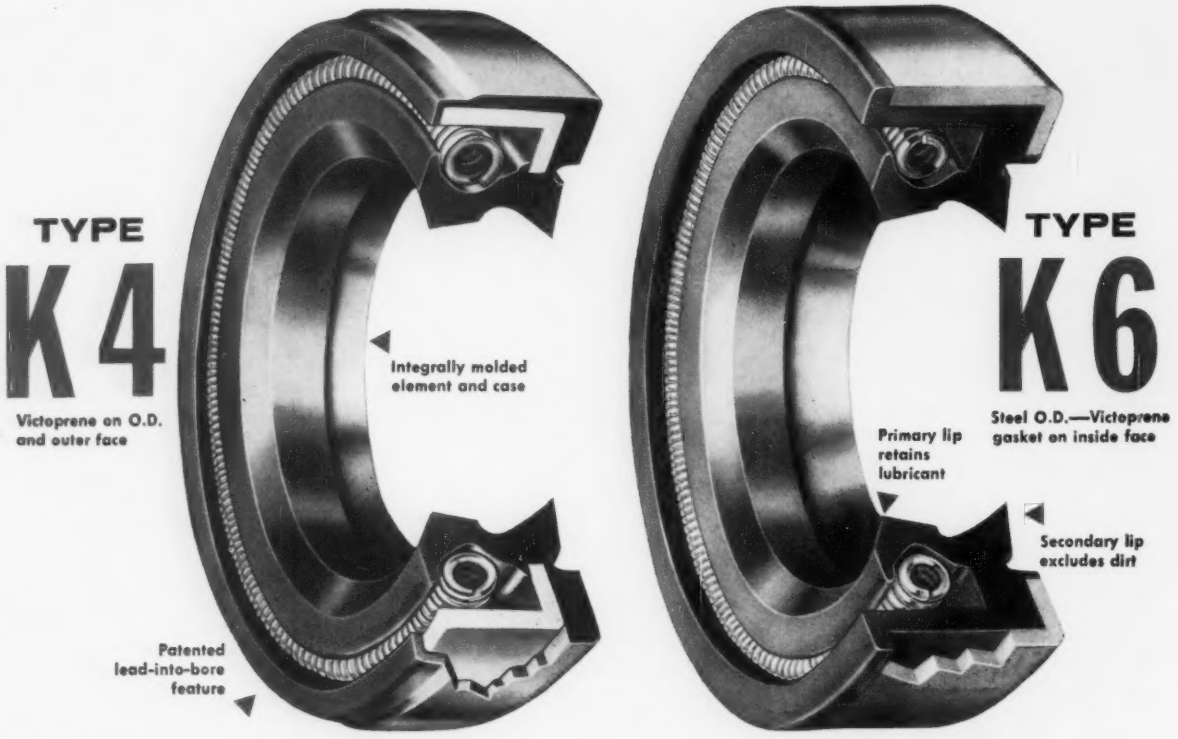
THE DIFFERENCE

ALWAYS TIGHT! Severe shock or reversing loads cannot loosen the sheave. Tightening the pull-up bolts locks the split-tapered hub to the shaft as tight as if the sheaves were integrally cast with shaft. The set screw anchors the key in position.

COMPLETE STOCK! You can get Worthington QD sheave stock service anywhere in the U. S. More than 350 distributors carry Worthington sheaves and Worthington-Goodyear Green Seal V-belts. For 100 page Multi-V-Drive Manual on how to select the right sheave and V-belt write to Section 79-9, Worthington Corporation, Harrison, New Jersey.

WORTHINGTON

Circle 449 on Page 19



Newest design for compact dual-lip sealing

Two types . . . as narrow as ¼ inch

In Type K4 Victoprene oil seal and its variant, Type K6, Victor offers a highly improved version of compound element shaft sealing. The two types accommodate varying installation and bore sealing needs, yet provide identical shaft sealing efficiency in the smallest housing space.

Check the design features. See how these seals can enhance your specifications for all types of machinery or automotive applications. You'll like their moderate price, too—and fast availability in all standard sizes! See your Victor Oil Seal Catalog No. 305.

DUAL SEALING SURFACES—Inner lip designed for maximum fluid retention. Outer lip excludes foreign matter or confines a secondary lubricant.

VICTOPRENE ELEMENT—Developed of improved Buna N synthetic rubber for balanced resistance to lubricants, heat, and age deterioration.

PRE-LUBRICATION CAVITY between lips provides for permanent lubrication on installation. Reduces frictional drag; extends seal life.

SPACE-SAVING NARROW WIDTH — Patented one-piece, integrally molded element and case construction permits most compact seal housing.

POSITIVE SPRING LOCATION—Molded groove in sealing element holds garter spring in proper place to keep uniform pressure on shaft.

POSITIVE BORE SEALING—*Type K4* has bonded-to-case Victoprene on O.D. and outer face. Patented lead-in feature aligns seal for easy installation. *Type K6*, for metal-to-metal installations, has steel O.D., with integral gasket on inside face for bottom of bore seal.

TYPICAL APPLICATIONS—Wheel bearing seals on automotive vehicles, farm and road machinery, etc.; crankshaft; pinion; automotive transmission (rear extension housings); speed reducers; winches, etc.

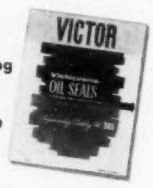
K4 and K6 seals supplied without spring where it is not required

Victor Mfg. & Gasket Co., P. O. Box 1333, Chicago 90, Ill.
Canadian Plant: St. Thomas, Ont.

VICTOR

Sealing Products Exclusively

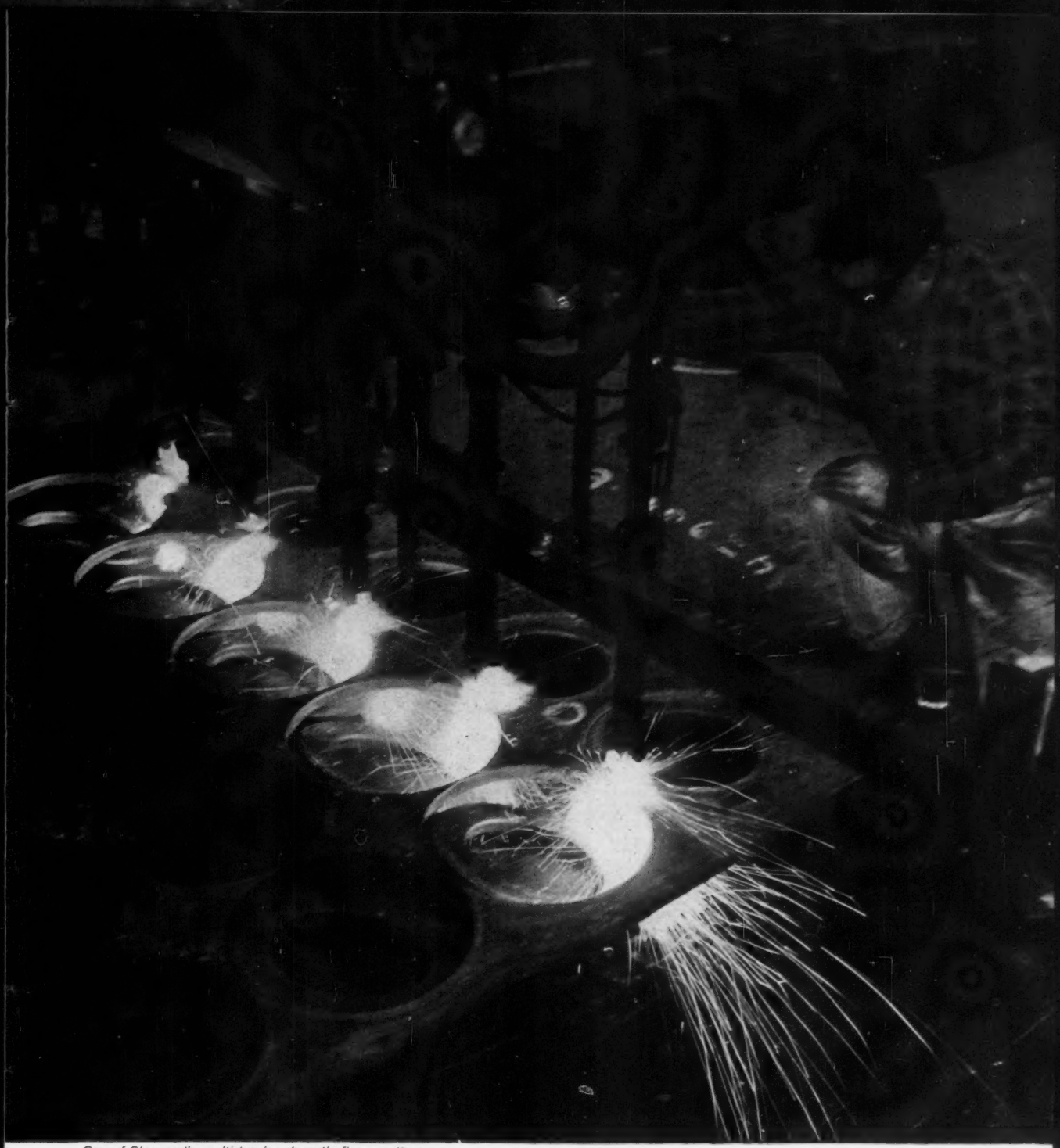
Victor Oil Seal Engineering Catalog No. 305, sent free on request. No designer should be without it.



OIL SEALS • GASKETS • PACKINGS • MECHANICAL SEALS

Circle 450 on Page 19

Circle 451 on Page 19→



One of Claymont's multi-torch automatic flame-cutters.

by d'Arnzien

Main feature of the Claymont story is integration. For instance, consider one phase of our operation—the new Fabrication Shop. First, steel from Claymont's own open hearth is formed into plate on Claymont's own rolling mills and sent to the Fabrication Shop. Here, modern equipment welds, shears, presses, rolls, cuts or machines the plate to produce fabricated products for many industries.

CLAYMONT
FABRICATED STEEL PRODUCTS

CF&I

CHECK CLAYMONT FOR—Alloy Steel Plates • Carbon Steel Plates • Stainless-Clad Steel Plates High Strength Low Alloy Steel Plates • CF&I Lectro-Clad Nickel Plated Steel Plates • Pressed and Spun Steel Heads • Manhole Fittings and Covers • Fabricated Steel Products Large Diameter Welded Steel Pipe

PRODUCTS OF WICKWIRE SPENCER STEEL DIVISION • THE COLORADO FUEL AND IRON CORPORATION

Plant at Claymont, Delaware • Sales Offices in all Key Cities

5787

Splices support All-Pro Tackle Lou Groza

The four corner splices in this extruded rubber windshield weather-strip produced by Ohio Rubber are strong enough to fully support 252-lb. All-Professional League Tackle Lou Groza of the Cleveland Browns, plus all his football gear.

Each of the four splices is a corner molded into an extruded weather-strip for perfect fit without tension. Neatness of splice, as well as strength, is an important factor because of the weather-strip's ultimate use in an automobile windshield assembly.

This ability to incorporate desired strength as well as neat appearance into splices is typical of ORCO's "customeering" of parts made from rubber, synthetic rubber, silicone rubber, polyurethane and flexible vinyl, whether they be molded, extruded or bonded to metal or other material.

ORCO's integrated research, design, electronically controlled mixing and production facilities assure component uniformity and quality to meet the most exacting requirements. Why not check with ORCO engineers on your very next rubber or vinyl component problem and see for yourself how ORCO CUSTOMEERING can work to your greater advantage.

Send for
free booklet
"Component
CUSTOMEERING
rubber and vinyl parts".

another example of **ORCO**

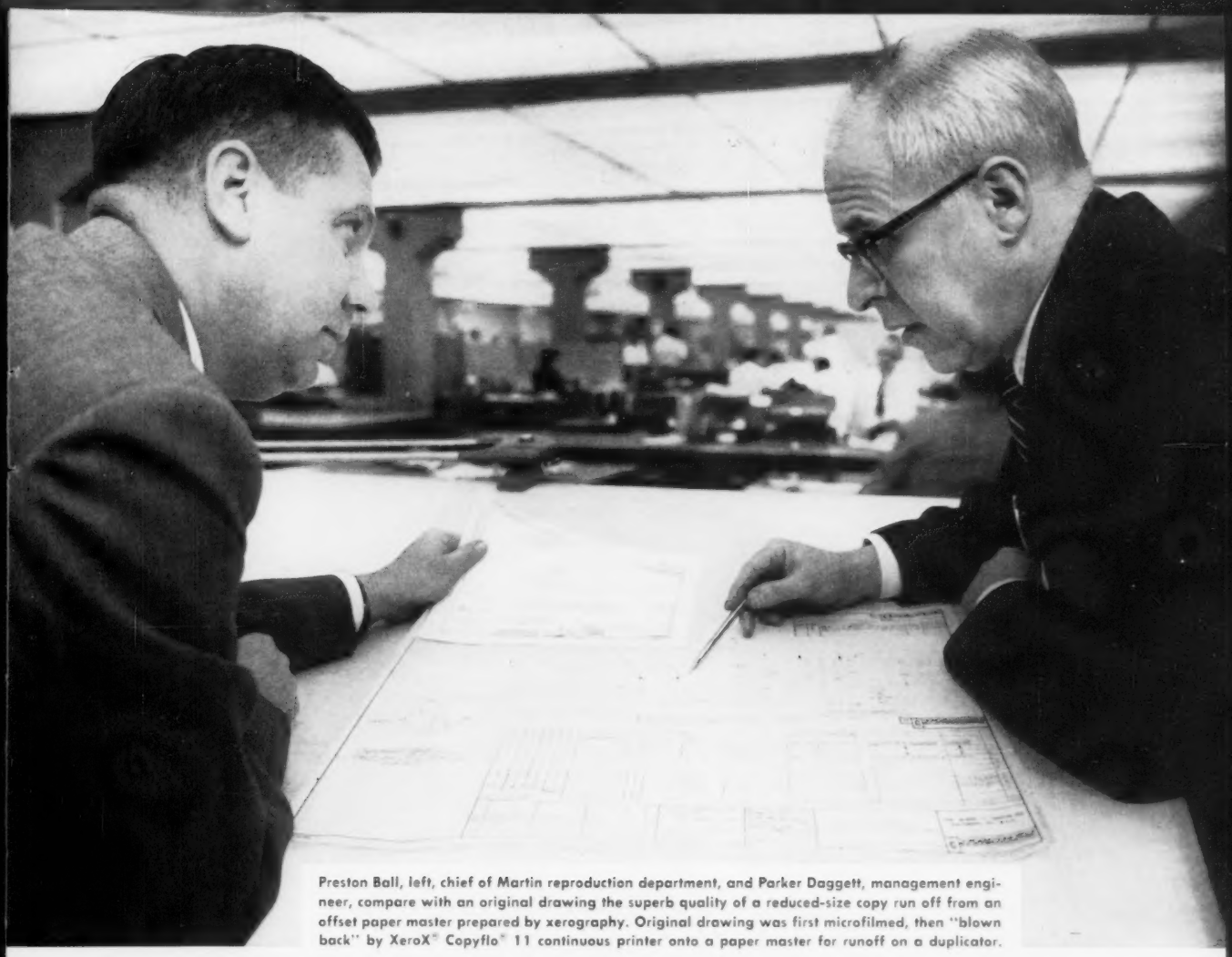
CUSTOMEERING

THE OHIO RUBBER COMPANY

WILLOUGHBY, OHIO

A DIVISION OF THE EAGLE-PICHER COMPANY

Circle 452 on Page 19



Preston Ball, left, chief of Martin reproduction department, and Parker Daggett, management engineer, compare with an original drawing the superb quality of a reduced-size copy run off from an offset paper master prepared by xerography. Original drawing was first microfilmed, then "blown back" by XeroX® Copyflo® 11 continuous printer onto a paper master for runoff on a duplicator.

thanks to *automatic* xerography . . .

MARTIN BALTIMORE saves $85,000 yearly

A XeroX® Copyflo® 11 continuous printer, enlarging disposable microfilm onto a continuous roll of offset paper masters, is saving Martin of Baltimore $85,000 a year in the reproduction of engineering drawings and drawing-change notices.

The Copyflo continuous printer, operating on the electrostatic principles of xerography, is completely automatic, enlarging microfilmed engineering drawings and change notices onto a continuous roll of inexpensive, offset-paper-master stock. This roll, 2,000 feet long by 12 inches wide, is then cut apart into individual masters for the runoff of multiple copies on offset duplicators.

Here are some of the advantages of the Copyflo 11 continuous printer to Martin of Baltimore:

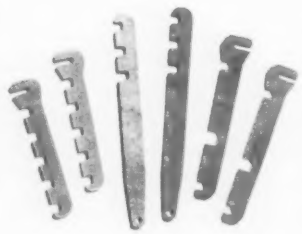
- Annual savings of $85,000.
- Output of offset paper masters has doubled, with 50% reduction of personnel and duplicating equipment.
- Average of 20 minutes saved in engineering department on each of 50,000 yearly change notices.
- Improved quality of runoff copies.
- Specification books, training manuals, etc., now printed in half of former time, with half the paper and half the collating.

Where the copying of a few or thousands of *different* documents is needed daily, look to automatic xerography for the convincing answer. Copyflo printers enlarge, reduce, or copy same size. They offer the speediest, most flexible, most economical method to get copies precisely like the original—either from the document itself or from microfilm. For complete information, write Haloid Xerox Inc., 58-189X Haloid St., Rochester 3, N. Y. Branch offices in principal U.S. and Canadian cities.

HALOID XEROX®

Circle 453 on Page 19

"S" is for Signal, Safety and Synthane



Typical pushers, machined from Synthane laminated plastics, used for railway signal relay.

Railroads can't even think in terms of failure. And that is why, among the many working parts that constitute railway signal relays, you find pushers made of Synthane laminated plastics.

These pushers, on which life itself depends, must in the words of one manufacturer have "excellent insulating characteristics—be durable and unchanging," must "not chip, wear and thus leave residual dust or particles which would cause trouble if they should lodge on the electrical contacts."

Synthane has all of these characteristics plus a combination of many other useful properties required for reliable performance. Equally important is the dependability of Synthane, the company, as a source of supply. You are urged to visit us and see for yourself the plant behind Synthane sheets, rods, tubes and fabricated parts—or to discuss this important point with our representative. Meanwhile, write for our new, complete catalog.

SYNTHANE

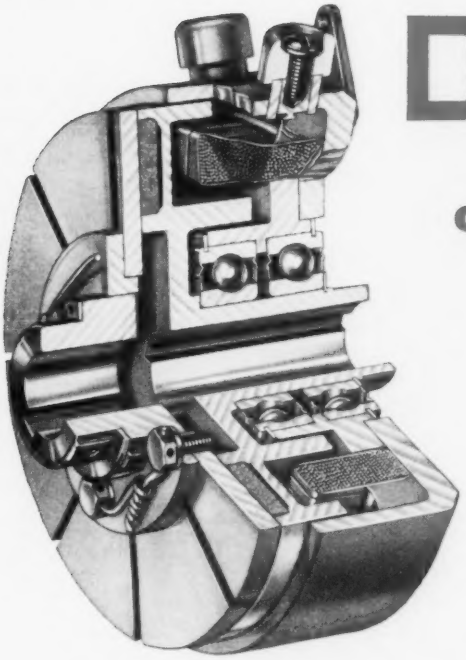
SYNTHANE CORPORATION, 5 RIVER ROAD, OAKS, PA.

Circle 454 on Page 19

New–Small Sizes!

EATON DYNA-TORQ

MAGNETIC-FRICTION CLUTCHES and BRAKES



STATIONARY-FIELD, BEARING-MOUNTED DYNA-TORQ CLUTCH

Now Available in a Full Line from 1¾" to 15" Diameter

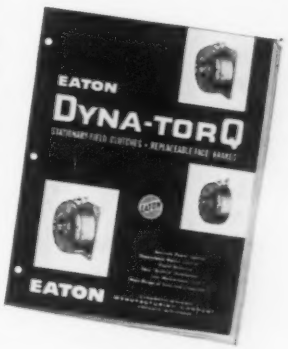
Eaton Dyna-torQ Magnetic-Friction Clutches and Brakes provide a simple, accurate, responsive method of controlling power and motion in today's complex production and processing machines.

The new smaller sizes and new design types of Dyna-torQ Stationary-Field Clutches and Brakes enable Eaton to offer a well rounded line, including flange-mounted and bearing-mounted clutches, and replaceable-face brakes. Unique features of design and construction result in worthwhile maintenance cost savings. Dyna-torQ units, easily and quickly installed on new machines or existing plant equipment, deliver many highly desirable advantages.

Dyna-torQ Magnetic-Friction Equipment Offers these Important Advantages:

- ★ Accurate power control
- ★ Dependable motion control
- ★ Rapid response
- ★ Easy "built-in" installation
- ★ Low maintenance costs
- ★ Compact plug-in type controls—may be remotely mounted
- ★ Inter-changeability of parts

Send for this new illustrated bulletin giving complete description and specifications covering Dyna-torQ Stationary-Field Clutches and Replaceable-Face Brakes.



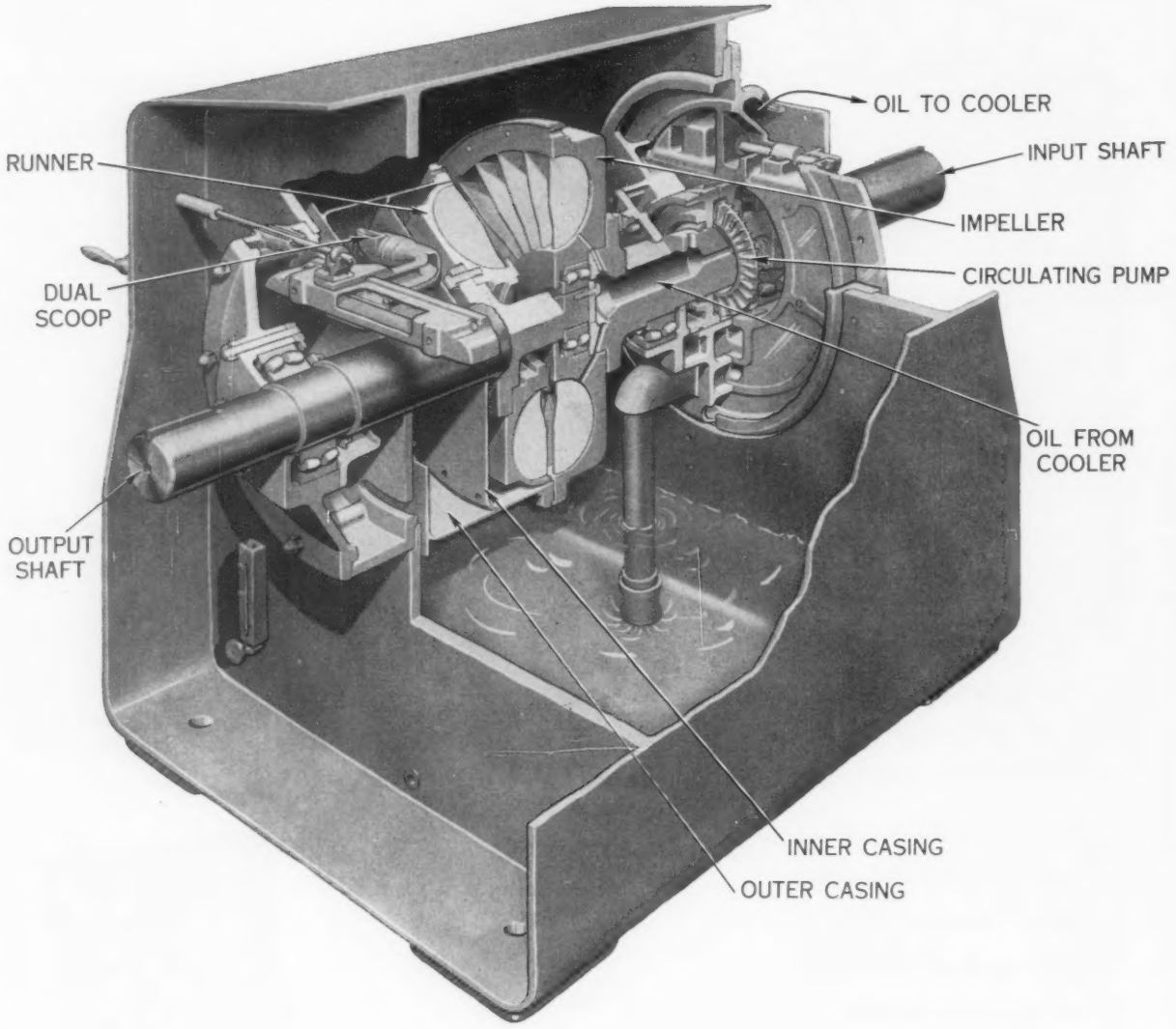
EATON

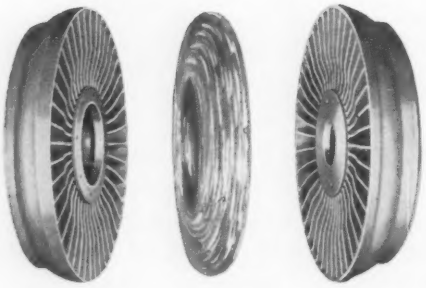
Dyna-torQ Equipment is Available through Dynamatic Distributors in all Leading Cities

EATON DYNAMATIC DIVISION
MANUFACTURING COMPANY
3307 FOURTEENTH AVENUE • KENOSHA, WISCONSIN

Circle 455 on Page 19

Now! More than through *GÝROL*® Fluid





Type VS, Class 2 Gýrol Fluid Drive—in sizes from 1 to 800 hp—adapts to automatic or manual control, has no mechanical connections between driving and driven shafts to cause friction-wear.

Using a vortex of oil to transmit power, Gýrol units provide simplicity of design, quietness, and flexibility offered by no other method of power transmission.

4,000,000 hp driven Drive...Here's why:

1 No-load starting—Gýrol Fluid Drive simplifies starting equipment because it permits the motor to reach operating speed before engaging the driven machine. Result: Motor can in many cases be selected for the running load—over-motoring for hard-to-start loads can usually be avoided.

2 Smooth, easy starting—Gýrol Fluid Drive provides infinite speed adjustments—accelerates loads without steps or bumps.

3 Controlled acceleration—Adjustable-speed Gýrol Fluid Drive allows fully controlled rate of acceleration—as slow or as rapid as required for specific processes, and to prevent overloading the motor.

4 Clutch and declutch action—Adjustable-speed Gýrol Fluid Drives have the ability to essentially declutch motors from their loads. When synchronous motors are used, the improvement in power factor can be gained at all times whether or not the driven machine is in operation.

5 Stepless, adjustable speed—Gýrol Fluid Drive's smooth, stepless speed control over the entire operating range makes it possible to run the driven machine at the exact speed required.

6 Isolation of torsionals—A Gýrol Fluid Drive transmits power through a cushion of oil with no mechanical connection. Shocks and torsional vibrations, originating from either driving or driven equipment, are isolated.

7 Limit against overload—Gýrol Fluid Drive has a definite maximum torque-transmitting capacity—governed by oil-fill size and input speed—which serves to protect both motor and driven machine against excessive overload.

8 Braking—Because Gýrol Fluid Drive can operate with input and output members rotating in different directions, dynamic braking for either intermittent or continuous duty is possible. Two proved applications: rapid deceleration of high WR^2 loads, and continual braking of paper unwinder rolls.

9 Minimum maintenance—Gýrol Fluid Drive has no mechanical connection between driving and driven shafts—no friction devices such as belts, clutches or sheaves to wear—no vacuum tubes, slip rings, brushes, or other electrical components to break or fail. Its non-wearing power-transmission medium—a vortex of oil—provides extra-long service life.

10 Wear or erosion reduction—On pumps, fans, or compressors, adjustable-speed Gýrol Fluid Drive permits lower average speeds than throttle-control with dampers or valves—greatly reduces erosion caused by particles in the air or liquid handled.

11 Reversible operation—All constant-speed and some adjustable-speed Gýrol Fluid Drives are completely reversible by reversing the motor—give identical performance in either direction of rotation.

12 Power savings—By providing stepless speed control without wasteful throttling, Gýrol Fluid Drive cuts horsepower consumption on centrifugal machines such as fans, compressors or pumps.

Thousands of industrial-drive applications have *proved* the advantages of American Blower Gýrol Fluid Drive in cutting power, equipment and maintenance costs. It answers virtually every power-transmission need involving adjustable-speed drive.

Send this coupon today for full details on the Type VS, Class 2 Gýrol Fluid Drive featured here . . . and other types that handle up to 12,000 hp. Or contact one of our 73 branch offices direct. American-Standard,* American Blower Division, Detroit 32, Michigan. In Canada: Canadian Sirocco products, Windsor, Ontario.

American-Standard
AMERICAN BLOWER DIVISION

*American-Standard and Standard are trademarks of American Radiator & Standard Sanitary Corporation.

American-Standard, American Blower Division,
Gýrol Fluid Drive Dept. 13-108, Detroit 32, Mich.

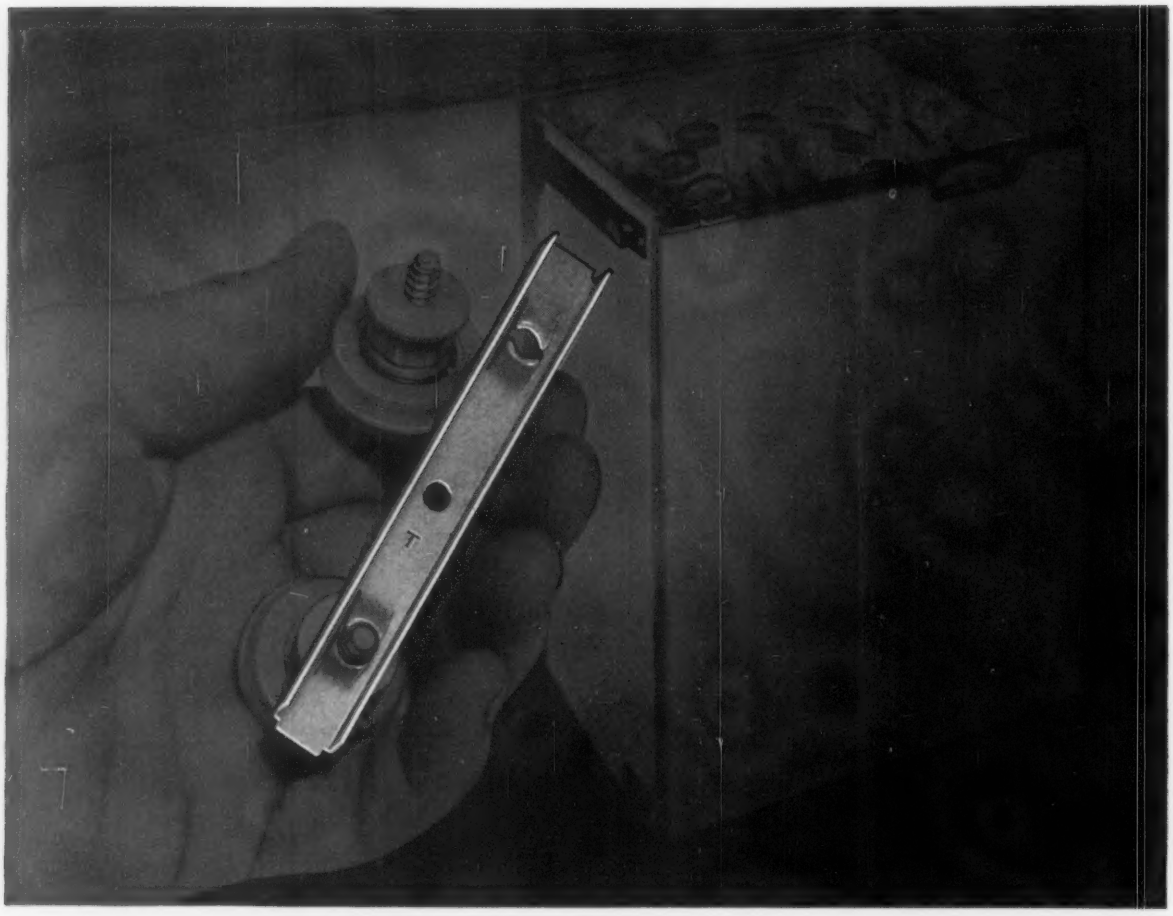
Please send full details on Gýrol Fluid Drive for the following application:

Name

Title

Firm

City and Zone State



Engineered by Tinnerman...

Savings pyramided 68% by a switch to TINNERMAN SPEED NUTS®

First, the saving in material on the General Electric Dishwasher . . . a Tinnerman SPEED NUT brand fastener is formed right in a channel stamped from high-carbon spring steel. This replaces a costly solid steel bar formerly used to mount the pull-out basket rollers.

Next, the Tinnerman SPEED NUT impressions are stamped right in the channel; expensive boring and tapping of the bar stock are eliminated.

Third, sheet metal screws hold tight in the SPEED NUT, and are easier to start and drive than the machine screws formerly used.

General Electric's dishwasher production goes faster and assembly costs are reduced by the easy-to-apply feature of the simplified SPEED NUT part. The difference in weight even makes an important reduction in freight costs on each carload shipment of dishwashers.

What Tinnerman SPEED NUTS accomplished for General Electric can probably be done for you.

A call to your Tinnerman Sales Representative will be the start. He's in the Yellow Pages under "Fasteners".

Or write to:

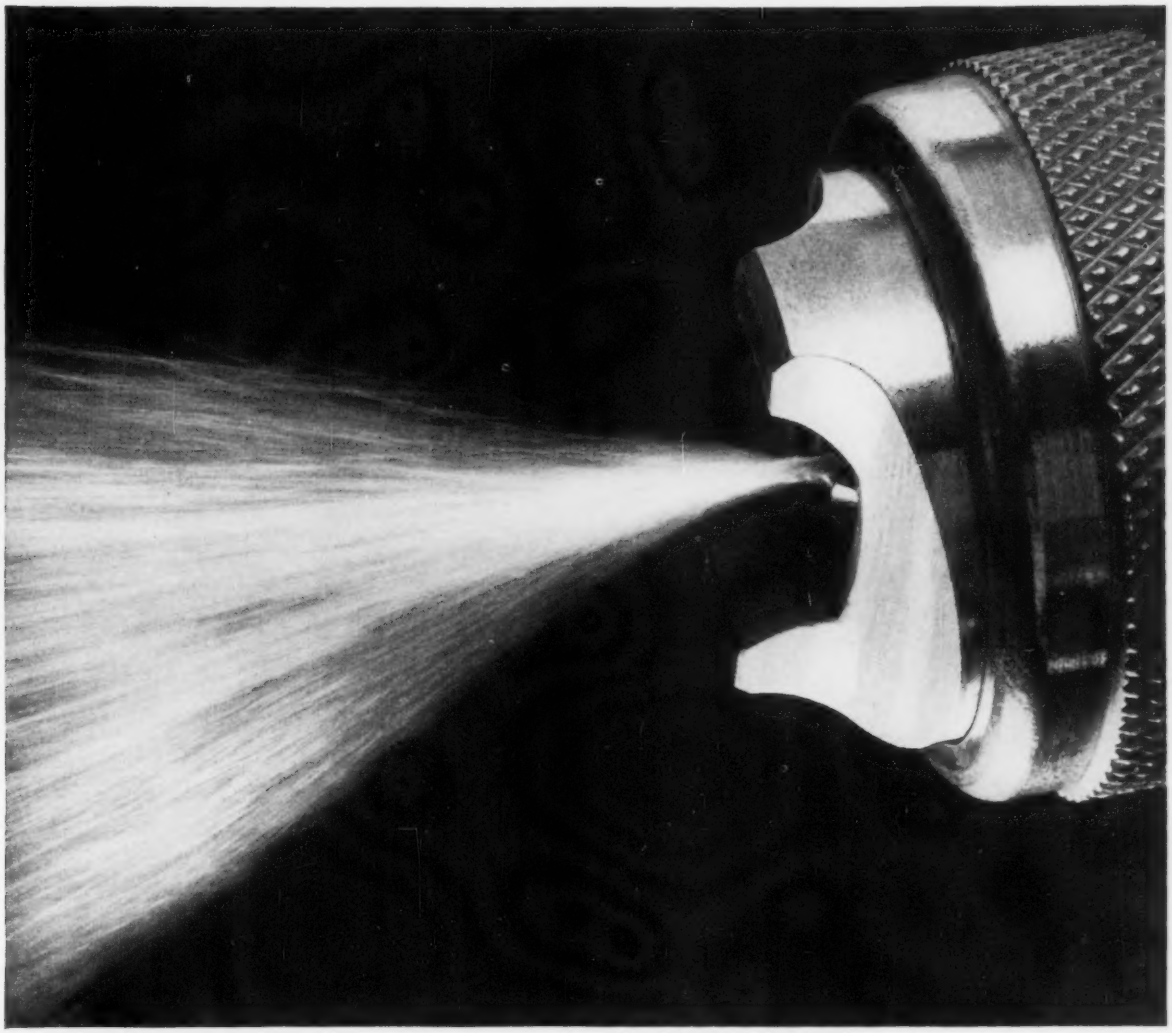
TINNERMAN PRODUCTS, INC.
Dept. 12 • P.O. Box 6688 • Cleveland 1, Ohio

TINNERMAN
Speed Nuts®

FASTEST THING IN FASTENINGS®

CANADA: Dominion Fasteners Ltd., Hamilton, Ontario. GREAT BRITAIN: Simmonds Aerocessories Ltd., Truforest, Wales. FRANCE: Simmonds S. A., 3 rue Salomon de Rothschild, Suresnes (Seine). GERMANY: Mecano-Bundy GmbH, Heidelberg.

EC-1357 by 3M Sprays on Smoothly for Stronger Sandwich Bonds!



3M ADHESIVE EC-1357 MINIMIZES COBWEBBING IN SPRAY APPLICATIONS FOR BETTER SURFACE-WETTING, FAR BETTER ADHESION.

Solvent blending makes the big difference! Exact amounts of several solvents are skillfully mixed to achieve the precise blend required for a superior sandwich-bonding adhesive. The result: spray application is easier, greatly reduced cobwebbing saves materials, better surface-wetting provides far better skin-to-core adhesion.

With EC-1357, sandwich structures can be bonded on a cold press or nip roller to provide high ultimate strength.

For use with or without force-drying, EC-1357 can be adapted to the widest variation in production-line techniques and speeds. Good to excellent immediate bonding strengths are achieved, depending on the drying method used. Because it is dark-colored, EC-1357 absorbs infrared heat fast. For a similar, light-colored adhesive, investigate EC-1368.

The high moisture- and weather-resistance of EC-1357 and EC-1368, plus their capacity to hold fast through a wide temperature range, make them ideal in unusually severe climates.

SEE WHAT 3M ADHESIVES CAN DO FOR YOU! For technical assistance, contact any one of our 19 branch offices located in principal cities throughout the United States. Six plants provide local service for faster delivery. For free literature, write on your company letterhead to: 3M, Dept. C-10, 417 Piquette Ave., Detroit 2, Michigan.

ADHESIVES, COATINGS AND SEALERS DIVISION

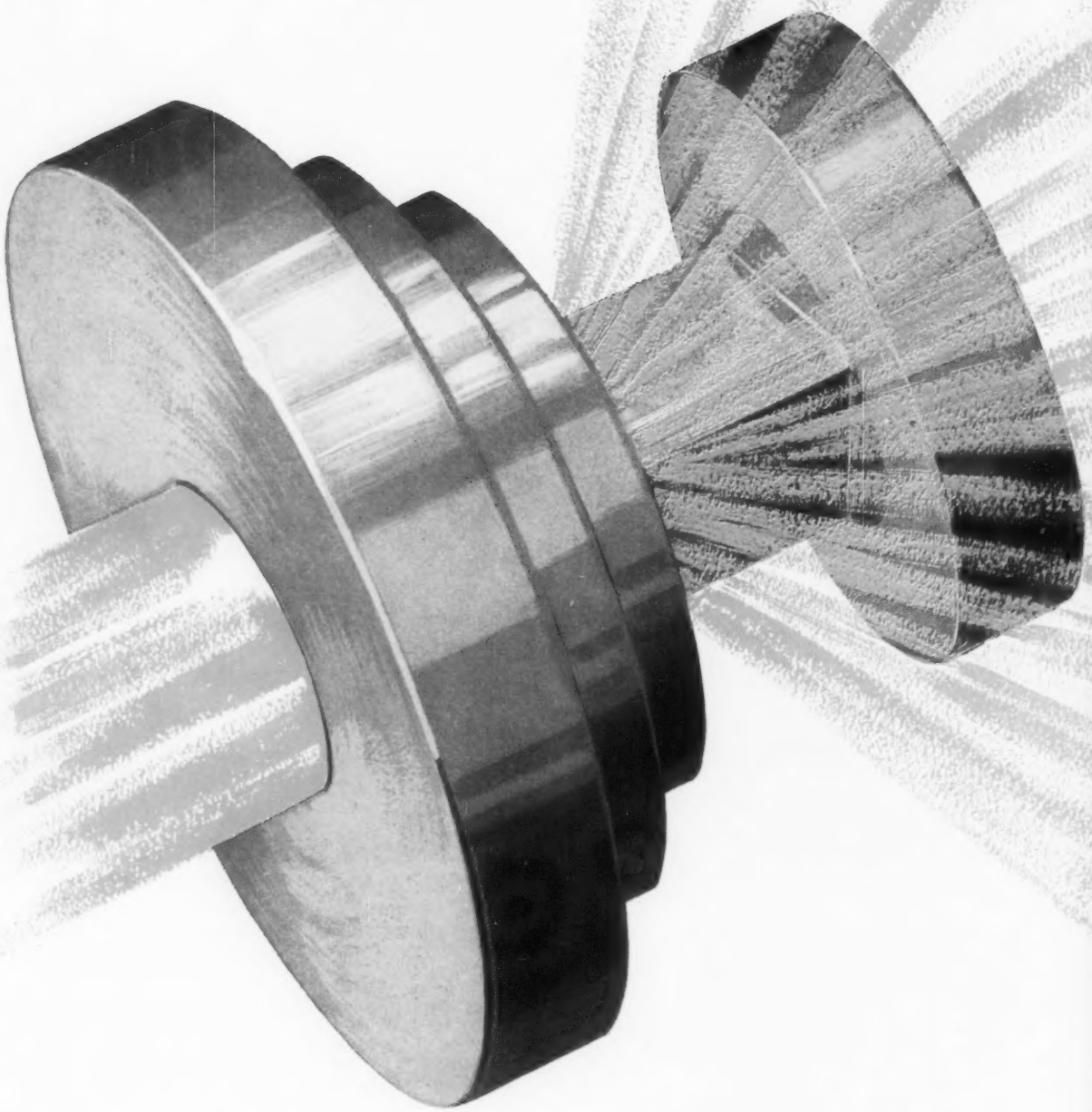
MINNESOTA MINING AND MANUFACTURING COMPANY

... WHERE RESEARCH IS THE KEY TO TOMORROW

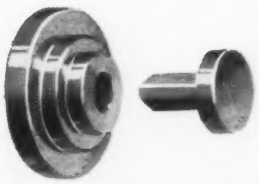
3M COMPANY

Circle 458 on Page 19

FOR THE MACHINERY PART



THAT TAKES THE BEATING



Liquids forced at high pressure through restricting valves—of HAYNES STELLITE alloy! That's the modern way by which hundreds of products are homogenized today, to make better dairy, chemical, food, and textile products, to name a few.

HAYNES alloys have been a standard material for homogenizer valves for 25 years. Valves that remain free from roughness, porosity, sharp corners, pits. Valves that retain their dimensions where pressures may reach 15,000 psi, and liquid velocities exceed 30,000 ft. per minute. Valves that keep products clean and free from contamination and give long service despite corrosive and abrasive conditions.

If design and production in your field call for tough metal parts, look into HAYNES alloys. There are more than 15 to choose from including HAYNES STELLITE cobalt-base alloys, HAYNES iron-base alloys, HAYSTELLITE cast tungsten carbide, and HASTELLOY nickel-base alloys. They are available as castings forgings, completely fabricated parts, or as sheet and bar stock. All parts can be furnished machined or ground to specified size and finish.

Our engineers will help you pick the right HAYNES alloy to resist practically any condition of wear, heat, or corrosion. For more information write for descriptive literature.

HAYNES Alloys *will do the job!*

HAYNES ALLOYS

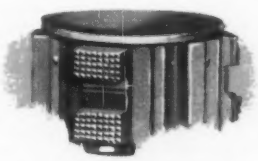
HAYNES STELLITE COMPANY

Division of
Union Carbide Corporation
Kokomo, Indiana

UNION CARBIDE

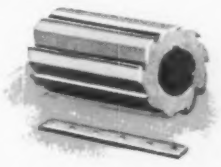
The terms "Haynes," "Haynes Stellite," "Hastelloy," "Haystellite," and "Union Carbide" are registered trade-marks of Union Carbide Corporation.

TYPICAL "HAYNES" ALLOY MACHINERY PARTS



Chuck inserts of HAYNES STELLITE alloy last up to 50 days—2 shifts daily—holding heavy pieces during a cut-off operation.

Seam rollers on milk-can machines turn out 2 to 3 times as many cans now that the rollers are made of HAYNES STELLITE alloy.

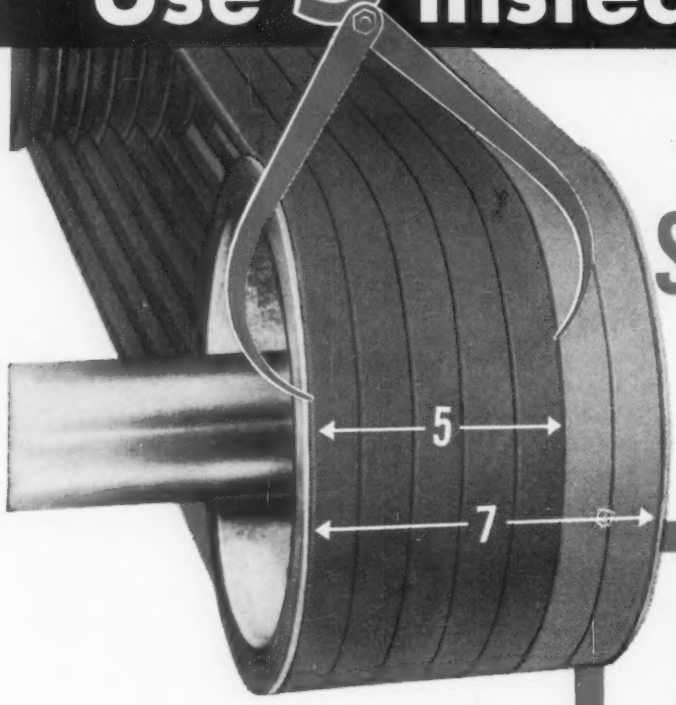


Cutters and bed knives made of HAYNES STELLITE alloy stay clean and sharp for years while pelletizing extruded polystyrene.

Circle 459 on Page 19

Use 5 instead of 7...

save { space / weight / cost



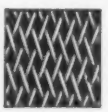
No other V-Belt has ALL these advantages

Money-saving fact: **A Gates Super Vulco Rope Drive delivers more HP per dollar invested than *any* standard V-belt drive.**

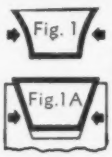
By using belts with 40% more horsepower capacity, you reduce sheave width and weight — save substantially in overall costs.

A wealth of drive data is always quickly available to you. Whether you need drive design service — or V-belts — or sheaves — just call your nearby Gates Distributor for a Gates V-Belt specialist.

Stocks carried in industrial centers throughout the world.



1. Flex-Weave Cover (U.S. Pat. 2519590)
A Gates exclusive: provides greater flexibility with far less stress on fabric. Cover wears longer... increases belt life... more power available to driven machine.



2. Concave Sidewalls (U.S. Pat. 1813698)
Concave sides (Fig. 1) increase belt life. As belt bends, concave sidewalls become straight, making uniform contact with sheave groove (Fig. 1A). Uniform contact means less wear on sides of belt... far longer belt life.

3. Tough, resilient Tensile Cords
Super-strong resilient tensile cords provide 40% greater horsepower capacity ... easily absorb heavy shock loads ... reduce number of belts required ... save weight and space

4. High Electrical Conductivity
Built into Gates Super Vulco Ropes for safer drives (in explosive atmospheres).

5. Oil, Heat, Weather Resistant
Special rubber compounds make Super Vulco Ropes highly resistant to heat, oil, and prolonged exposure to weather.

TPA 341

Gates Distributors are in the Yellow Pages

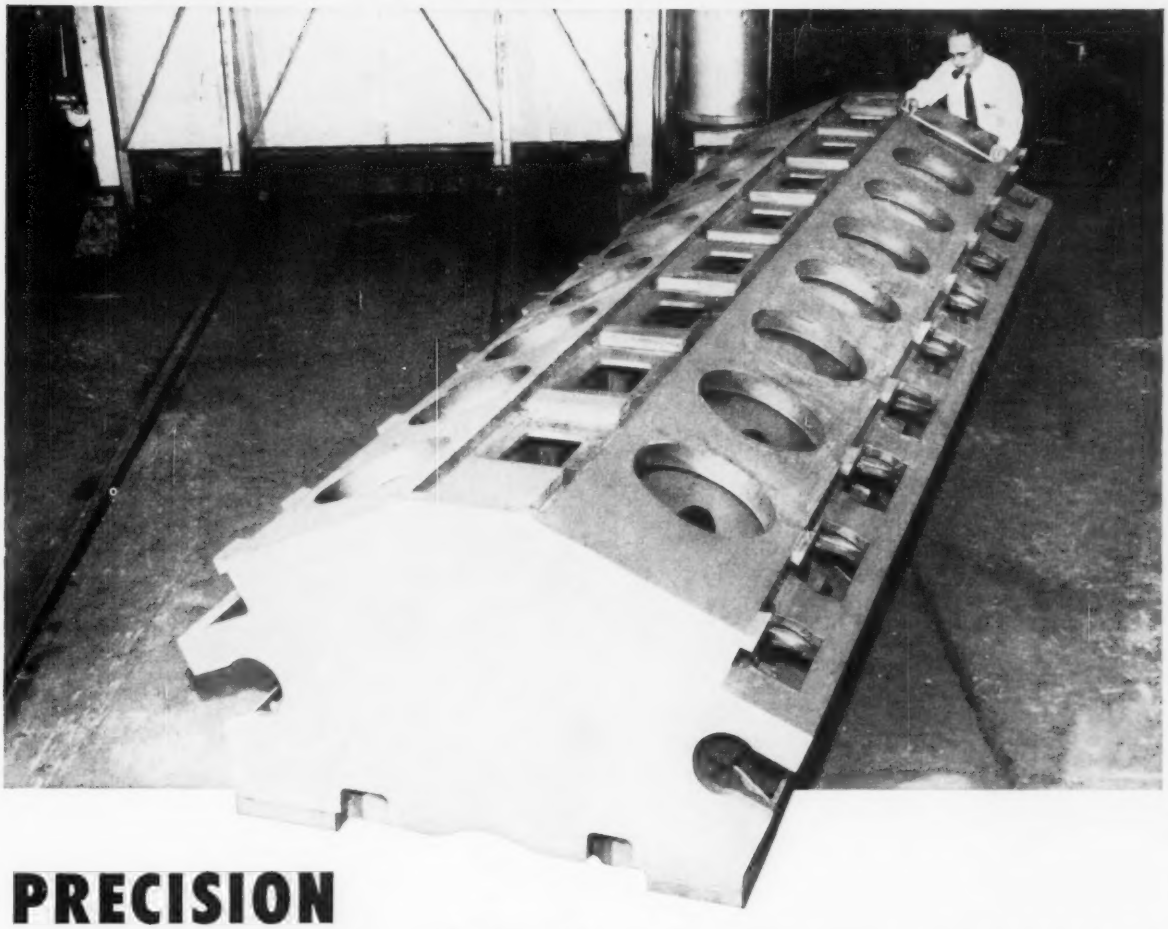
The Gates Rubber Company
Denver, Colorado
World's Largest Maker of V-Belts

Gates — The Mark of *Specialized* Research

Gates Super Vulco Rope Drives

40% more Horsepower Capacity

STEEL-WELD FABRICATION . . .



PRECISION
in Production of Weldments of Great Strength!

The heavy weldment above is the frame for a sixteen-cylinder, 5000 H.P. Diesel Engine. It is typical of the precision parts entrusted to Mahon for fabrication by hundreds of manufacturers throughout the country.

When you consider Steel-Weld Fabricated components for processing machinery, machine tools, or other types of heavy mechanical equipment, you, too, will want to discuss your requirements with Mahon engineers; because, in the Mahon organization you will find a unique source for weldments or welded steel in any form . . . a fully responsible source with a long and enviable performance record, and unusual facilities for design engineering, fabricating, machining and assembling.

See Sweet's Product Design File for information, or have a Mahon sales engineer call at your convenience.

Use WELDED STEEL for 100% Predictability and Greater Strength with Reduced Weight!

THE R. C. MAHON COMPANY • Detroit 34, Michigan

SALES-ENGINEERING OFFICES in DETROIT, NEW YORK and CHICAGO

MAHON

Circle 461 on Page 19

T-J spacemaker cylinder

Quality Engineered

to give quality results

with Extras . . .
at No Extra Cost!

You get more—much more—when you specify and use any of T-J's complete line of Spacemaker cylinders. The Spacemaker is engineered to give you better, more accurate, and longer service—offers, exclusively, many extras . . . that are STANDARD, AT NO EXTRA COST!

Designed to eliminate tie-rods, providing greater strength . . . saves space . . . reduces manhours and costs in all push-pull-lift operations. IMMEDIATE SHIPMENT in a wide range of styles and capacities, with 64,000 combinations. Write for Bulletin SM 155-3 with complete engineering details. The Tomkins-Johnson Co., Jackson, Mich.

T-J TOMKINS-JOHNSON
RIVETORS, AIR AND HYDRAULIC CYLINDERS, CUTTERS, CLINCHERS

METAL PISTON ROD SCRAPER . . . Standard at No Extra Cost!

NEW "SUPER" CUSHION FOR AIR . . . Standard at No Extra Cost!

CHROME PLATED CYLINDER BORES AND PISTON RODS . . . Standard at No Extra Cost!

ONE PIECE PISTON . . . Standard at No Extra Cost!

NEW "SELF-ALIGNING" MASTER CUSHION FOR HYDRAULIC USE . . . Standard at No Extra Cost!

NO TIE-RODS TO STRETCH . . . Standard at No Extra Cost!

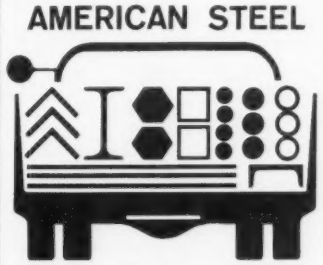
STREAMLINED DESIGN . . . Oil Pressure to 750 P.S.I.—air to 200 P.S.I. Standard at No Extra Cost!

FORGED SOLID STEEL HEADS . . . Standard at No Extra Cost!

Circle 462 on Page 19

Metal users, you can simplify... you can save money by standardizing on two alloy steels... 4620...4340 easy to get at your Steel Service Center

AMERICAN STEEL



WAREHOUSE ASS'N.

Standardize on AISI 4620 and 4340 and you standardize on fabricating and heat treating processes...

Simplify inventory and purchasing...

Save money by cutting production costs right down the line...

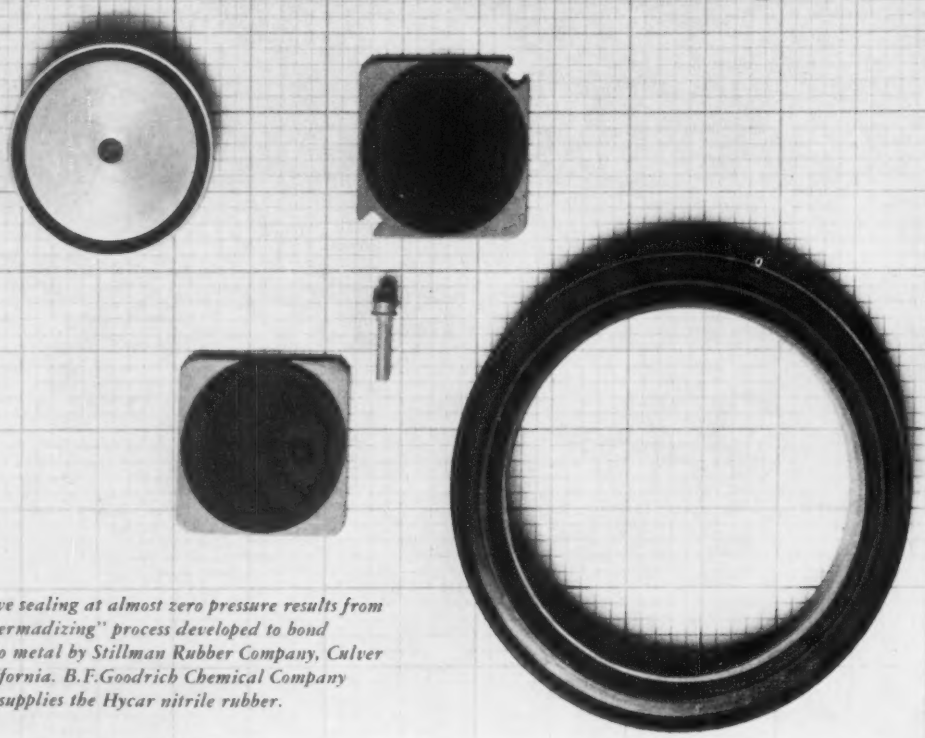
You standardize, simplify and save money when you use AISI 4620 and 4340...available coast-to-coast from Steel Service Centers. For a list of these sources write:

THE INTERNATIONAL NICKEL COMPANY, INC.

67 Wall Street INCO **New York 5, N. Y.**

Another new development using

B.F.Goodrich Chemical *raw materials*



Effective sealing at almost zero pressure results from use of "Permadizing" process developed to bond Hycar to metal by Stillman Rubber Company, Culver City, California. B.F.Goodrich Chemical Company supplies the Hycar nitrile rubber.

Optically-smooth precision rubber parts

...made possible by new Hycar-to-metal bonding

The seals above are made of rubber, they are ground to dimensional tolerances you usually expect only from metal. As a result, they can be used to seal fluids with a wider temperature range than ever before. They illustrate the advantages of using Hycar nitrile rubber bonded to metal. Hycar can be ground to dimensional tolerances as fine as 5 micro finish.

Oil-resistant Hycar can be used without fear of low temperature brittleness. Operating temperatures can be as low as –65°F. and as high as 250°F. Parts are also flash free.

The exceptional qualities and properties of Hycar lead to new applications or new products for many industries. You can get more information by writing Dept. KK-5, B.F.Goodrich Chemical Company, 3135 Euclid Avenue, Cleveland 15, Ohio. Cable address: Goodchemco. In Canada: Kitchener, Ontario.

Hycar
American Rubber

B.F.Goodrich Chemical Company
a division of The B.F.Goodrich Company

SEE US AT BOOTH NO. 508
8TH NATIONAL
PLASTICS
EXPOSITION
NOV. 17-21
INT'L AMPHITHEATRE—CHICAGO

B.F.Goodrich

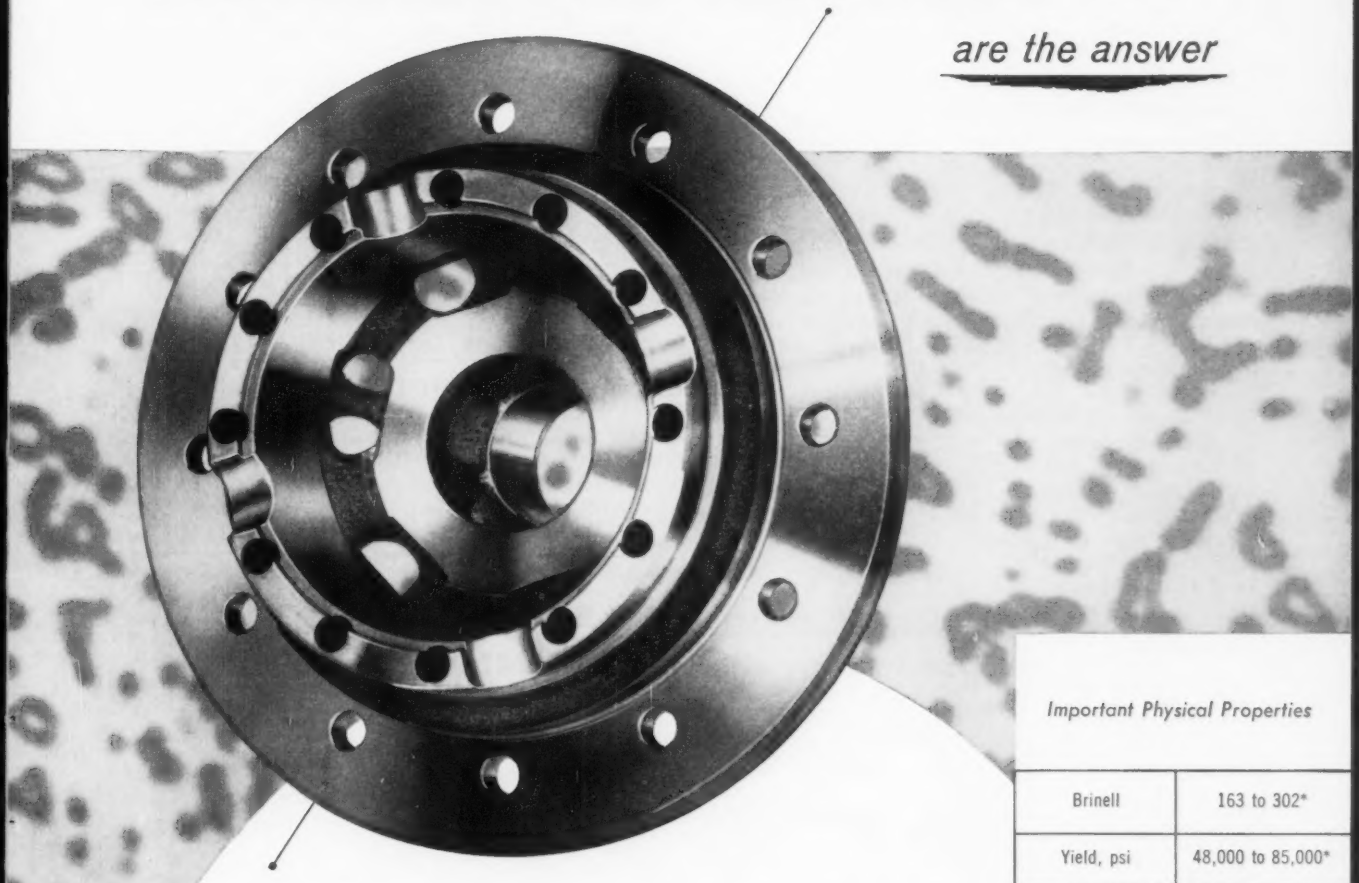
GEON polyvinyl materials • HYCAR American rubber and latex
GOOD-RITE chemicals and plasticizers • HARMON colors

is your problem

machinability?

NATIONAL HTM CASTINGS

are the answer



There are many reasons for specifying HTM (Pearlitic Malleable) castings for your product. One is *machinability of 70-90 percent* (B1112 steel = 100).

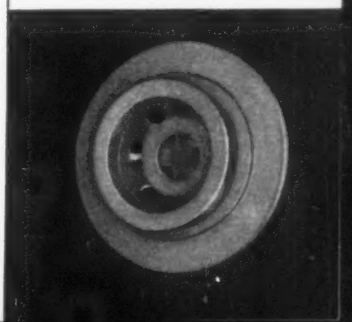
But there are many other equally valid reasons. High ultimate strength . . . extreme wear resistance under heavy loads and high speeds . . . non-seizing qualities . . . air or liquid quenching . . . ability to be smooth-finished.

So when you're looking over the materials field, don't overlook the advantages of HTM castings. For HTM metal can be cast by either the shell mold, CO_2, or green sand methods. This means production costs tumble . . . performance and saleability of your product go up.

Important Physical Properties

Brinell	163 to 302*
Yield, psi	48,000 to 85,000*
Ultimate, psi	70,000 to 110,000*
Elongation, %	7 to 2*

**Depending upon grade*



NATIONAL MALLEABLE and STEEL CASTINGS COMPANY

Established 1868 *Cleveland 6, Ohio*

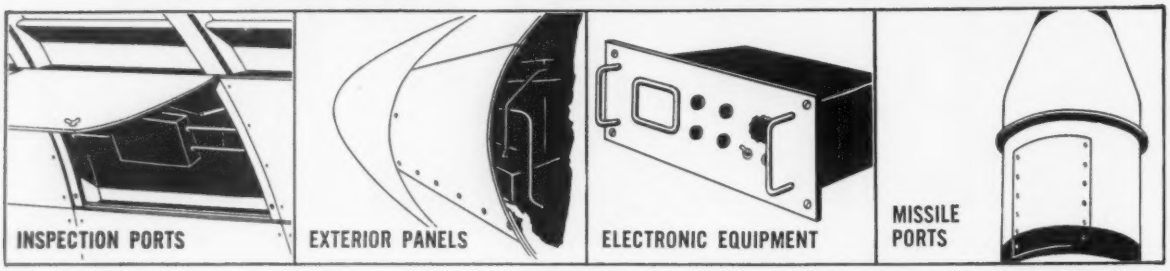
AA-6832

The nation's largest independent producer of malleable and pearlitic malleable

Circle 464 on Page 19

FLIGHT-PROVED RELIABILITY . . .

LION *Quarter-turn* FASTENERS FOR SECURING REMOVABLE SECTIONS

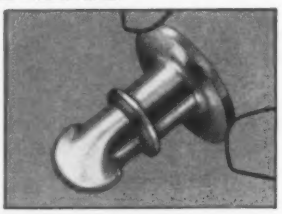


Southco's Lion Quarter-turn Fasteners provide quick access and reliable securing of hinged or completely removable panels. Resistance to severe heat, shock and vibration, and a high strength-weight ratio make these unique fasteners ideal for use in private, commercial or military aircraft and missiles . . . for ground production and control or airborne applications.

Lion Fasteners consist of three parts . . . a one-piece, swaged-nose stud; a retainer; a floating receptacle which is riveted or welded in place. Installation requires no special tools . . . is simplified by a permissible float of .070".

SWAGED NOSE

Case hardened one-piece stud with swaged nose has no milled sections, inserts, or cross pins . . . requires no wire spring to hold it in locked position. Lion Fasteners offer the highest weight-strength ratio available.



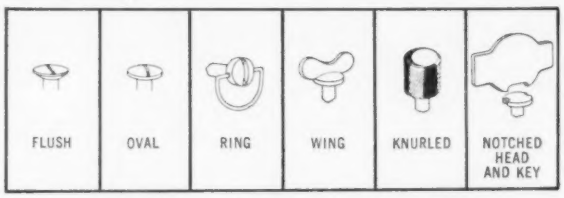
2 TYPES AVAILABLE

LION NO. 2 FASTENER
For use where space is limited and where weight must be kept at a minimum.

LION NO. 5 FASTENER
For heavy-duty applications where good tensile and shear strength are required.

FULL RANGE OF HEADS

Lion No. 2 Fastener available with flush, oval or wing type. No. 5 with flush, oval, ring, wing, knurled or notched head and key.



OTHER SPECIFICATIONS

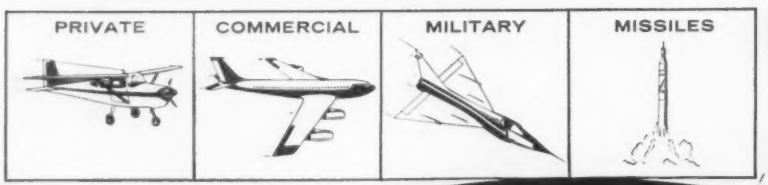
LION NO. 5 QUARTER-TURN FASTENERS CONFORM TO MIL. SPEC. MIL-F-5591A (ASG) . . . ARE ON THE GOVERNMENT'S QPL . . . ARE CAA APPROVED FOR COMMERCIAL AND PRIVATE AIRCRAFT USE.

MATERIAL: Cadmium-plated case-hardened steel.

FREE!

FASTENER HANDBOOK

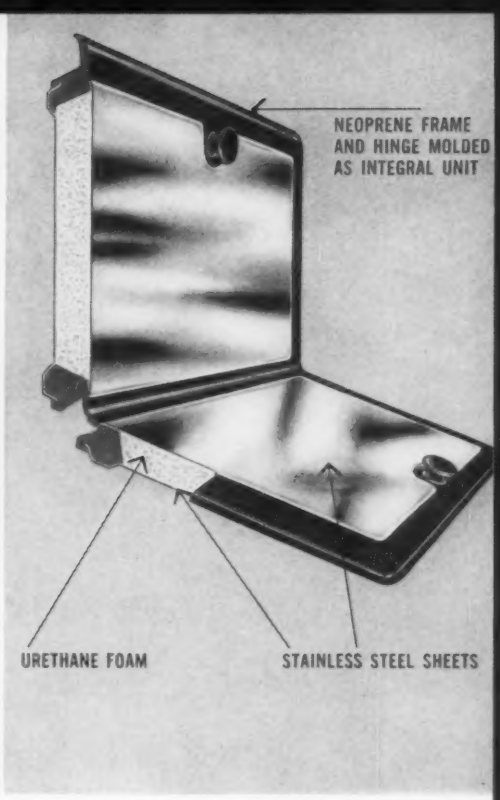
Send for your free copy of Southco Fastener Handbook No. 8. Gives complete engineering data on Lion Fasteners and many other special fasteners. Write to Southco Division, South Chester Corporation, 237 Industrial Highway, Lester, Pa.



LION *Aviation* FASTENERS

one of the SOUTHCO FASTENERS LION

©1958



No fasteners needed: hinged lid assembled within one-piece neoprene frame

The double frame of this ice cream cabinet lid—including hinge, lip seals and knobs—is a one-piece molding of neoprene synthetic rubber. Stainless steel panels and urethane foam-in-place insulation complete the design; not a single fastener is required.

Bottom panels are molded into the vulcanized neoprene frame. Neoprene adhesive is applied to the interior surfaces of the steel panels and urethane foam is poured into the cavities. The foam sets at room temperature to provide a lightweight insulation and stiffener. Tests of this lid have included 200,000 slammings with no flex-cracking in the neoprene hinge or other damage to the unit.

Du Pont neoprene is specified for the frame because it offers good mechanical properties; resistance to butterfat, shortening and fruit acids; and resistance to strong detergents and hot water. The frame is easy to clean and has no crevices to catch dirt.

Investigate the design possibilities of neoprene. It has a combination of properties which mean superior performance for many products: properties including resistance to oil, heat, many chemicals and weather. Send the coupon for more information on neoprene and two new Du Pont elastomers: HYPALON® and VITON.

ELASTOMERS IN ACTION HYPALON® • NEOPRENE VITON TRADEMARK

DU PONT
REG. U. S. PAT. OFF.

Better Things for Better Living
. . . through Chemistry

Circle 468 on Page 19

☐ I am particularly interested in _____

☐ Send me a free copy of *The Du Pont Elastomers* (a review of properties of neoprene and HYPALON).

☐ Add my name to the free mailing list of the *Elastomers Notebook* (contains articles based on uses of Du Pont Elastomers in industry).

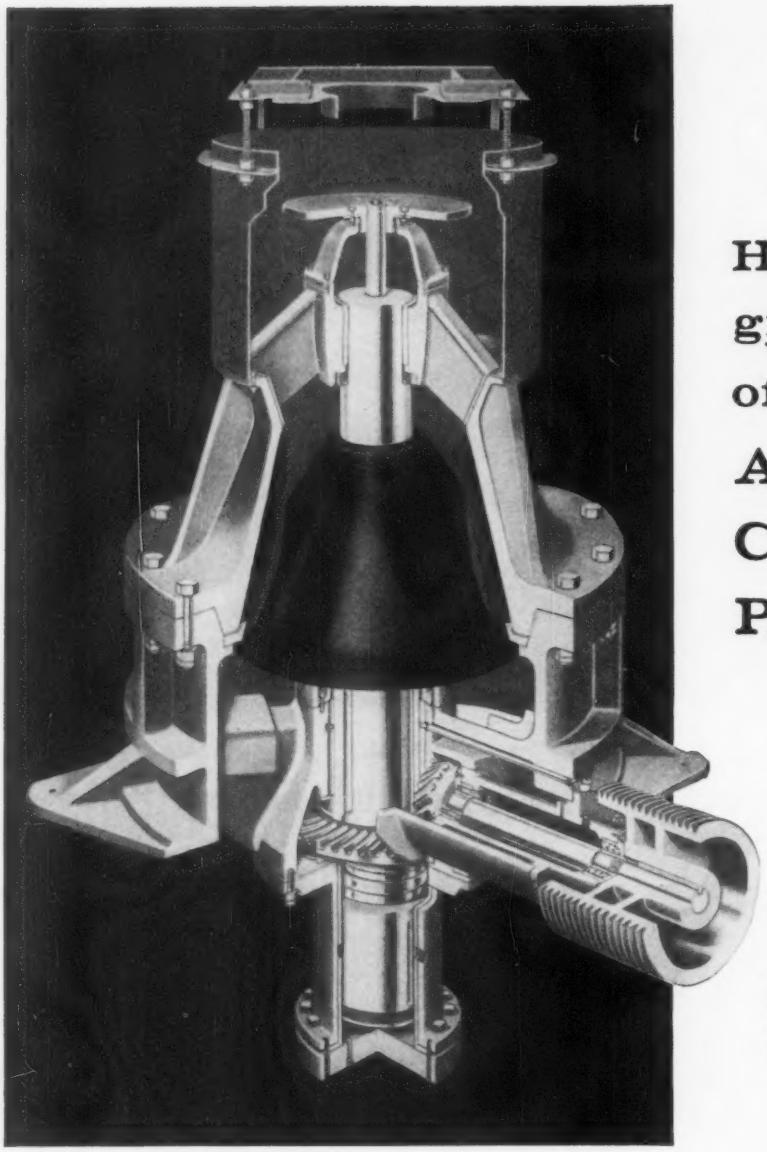
E. I. du Pont de Nemours & Co. (Inc.)
Elastomer Chemicals Dept. MD-10
Wilmington 98, Delaware

Name _____

Firm _____

Address _____

City _____ State _____



How a little give adds a lot of life to... AMSCO CRUSHER PARTS

Concave ring and mantle of this *Hydrocone* crusher are made of the toughest steel known... Amsco Manganese Steel. It *gives* a little, to take more punishment. *Hydrocone* is a registered trade-mark of the Allis-Chalmers Manufacturing Company.

Both mantle and concave ring crush a lot more feed because of certain properties of Amsco® Manganese Steel. The metal *gives* a little under crushing forces, absorbs stresses, resists cracking and chipping. Yet these same forces work-harden the surface of Amsco Manganese Steel to as much as 500 Brinell... a high hardness, stubborn to wear.

Amsco Manganese Steel Crusher Parts maintain their ductile undersurface and work-hardened surface even when worn thin. That's why Amsco parts endure severe abuse for so many work hours without letup.

To be sure of getting Amsco Manganese Steel, order replacement parts from your crusher manufacturer. Amsco makes manganese steel parts for most manufacturers of crushing, grinding and pulverizing equipment.

Amsco also produces other alloy steels with maximum wear resistance under particular service conditions

AMERICAN Brake Shoe COMPANY

AMSCO

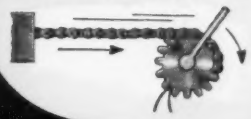
American Manganese Steel Division • Chicago Heights, Ill.

OTHER PLANTS IN: DENVER, LOS ANGELES, NEW CASTLE, DEL., OAKLAND, CAL., ST. LOUIS, JOLIETTE, QUEBEC

DIAMOND "FIRSTS"

in the development of Roller Chain

FIRST TO PRE-LOAD PRODUCTION ROLLER CHAIN

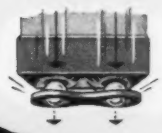


Pre-loading seats pins, bushings and linkplates; takes out initial stretch.

FIRST TO STUDY FATIGUE

First to make design changes in roller chain parts for improved fatigue resistance.

FIRST TO BALL DRIFT



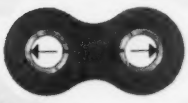
Pitch holes in DIAMOND chain sideplates are ball drifted for greater fatigue resistance—(DIAMOND patent).

FIRST TO EMPLOY SEAM RELIEF BUSHINGS

OIL RESERVOIR

Seam relief bushings in roller chain reduce run-in time and provide better lubrication—(DIAMOND original patent).

FIRST TO PROPERLY PLACE BUSHINGS



Bushing seams on DIAMOND roller chain are always placed *away* from load-bearing area for improved resistance to wear and fatigue.

FIRST TO SHOT PEEN

DIAMOND chain parts . . . rollers, bushings, linkplates and pins . . . are shot peened for greater fatigue resistance.

DIAMOND Roller Chains are the product of more than sixty-eight years of specialization in the manufacture of high endurance roller chain. Some of the quality features developed and pioneered by DIAMOND are considered "extra" or "premium" features in other chains. These are standard in DIAMOND Roller Chains . . . and have been for years. DIAMOND will continue to improve the capabilities of its product, assuring you *always* of a thoroughly dependable chain with superior operating characteristics.

Look for the ◇ on the Links

DIAMOND Distributors have all types and sizes of Roller Chain *in stock*, ready for instant delivery. Look under "Chains, Roller" in the Yellow Pages of your Telephone Directory . . . or write to factory for catalog and name of your nearest distributor.

Circle 470 on Page 19

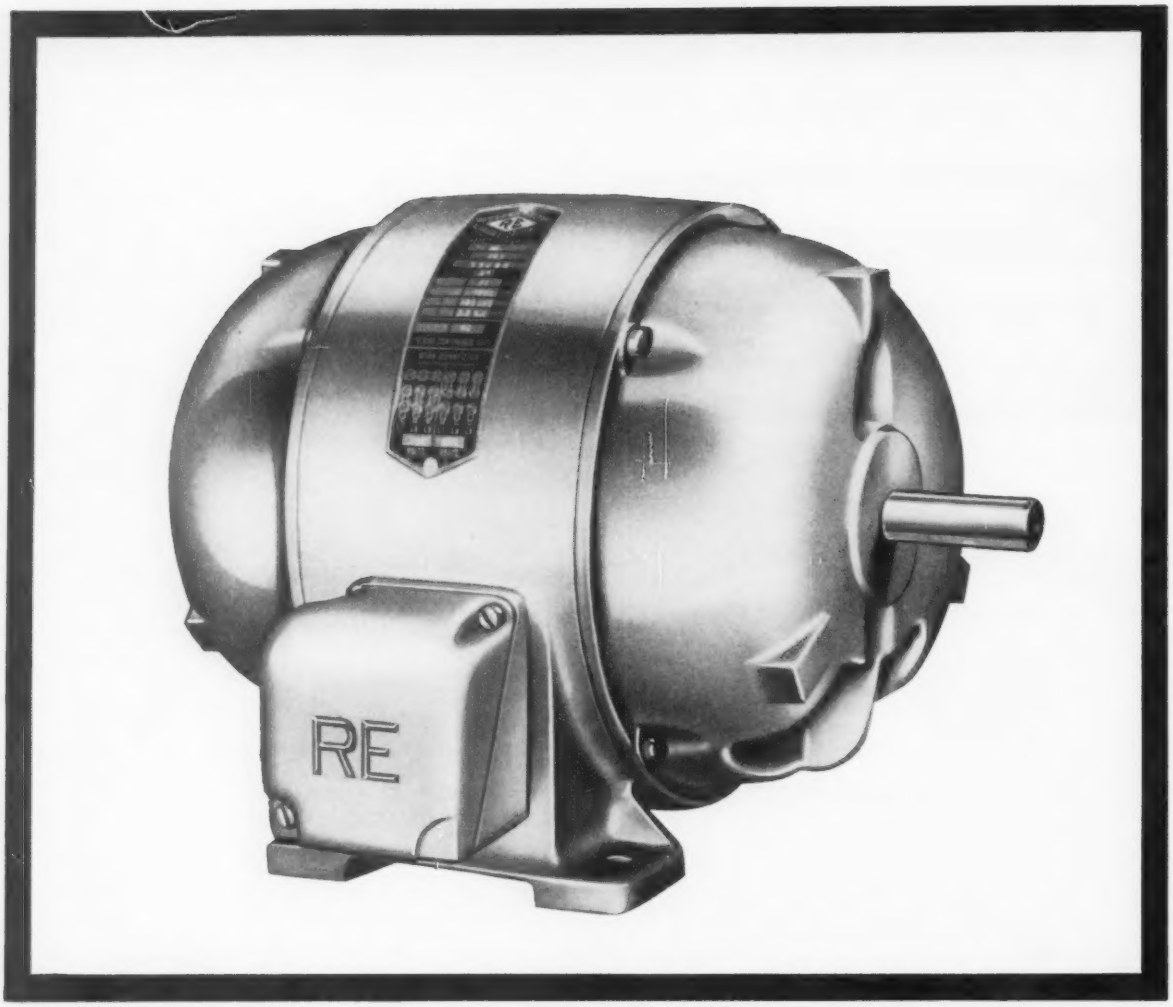
DIAMOND CHAIN COMPANY, INC.

A Subsidiary of American Steel Foundries

Dept. 435, 402 Kentucky Avenue, Indianapolis 7, Indiana

Offices and Distributors in All Principal Cities

DIAMOND **ROLLER CHAINS**



REULAND STANDS BEHIND ITS PRODUCTS

If you have purchased equipment on which Reuland motors are installed, you can be assured that this philosophy of doing business is built into every single Reuland motor you own... in as tangible a form as the metal itself. Not only as a standard "service policy"... but by the kind of understanding and consideration that comes only from a company dedicated to fairness and service.

Quite likely you will never have an occasion to draw on this policy, but it is reassuring to know that it is there, wherever you may be.

Yes, across the Nation . . . or around the globe, Reuland stands behind *every* product that bears its name... stands behind it with a great company-wide pride that can only bring you full satisfaction at every turn.

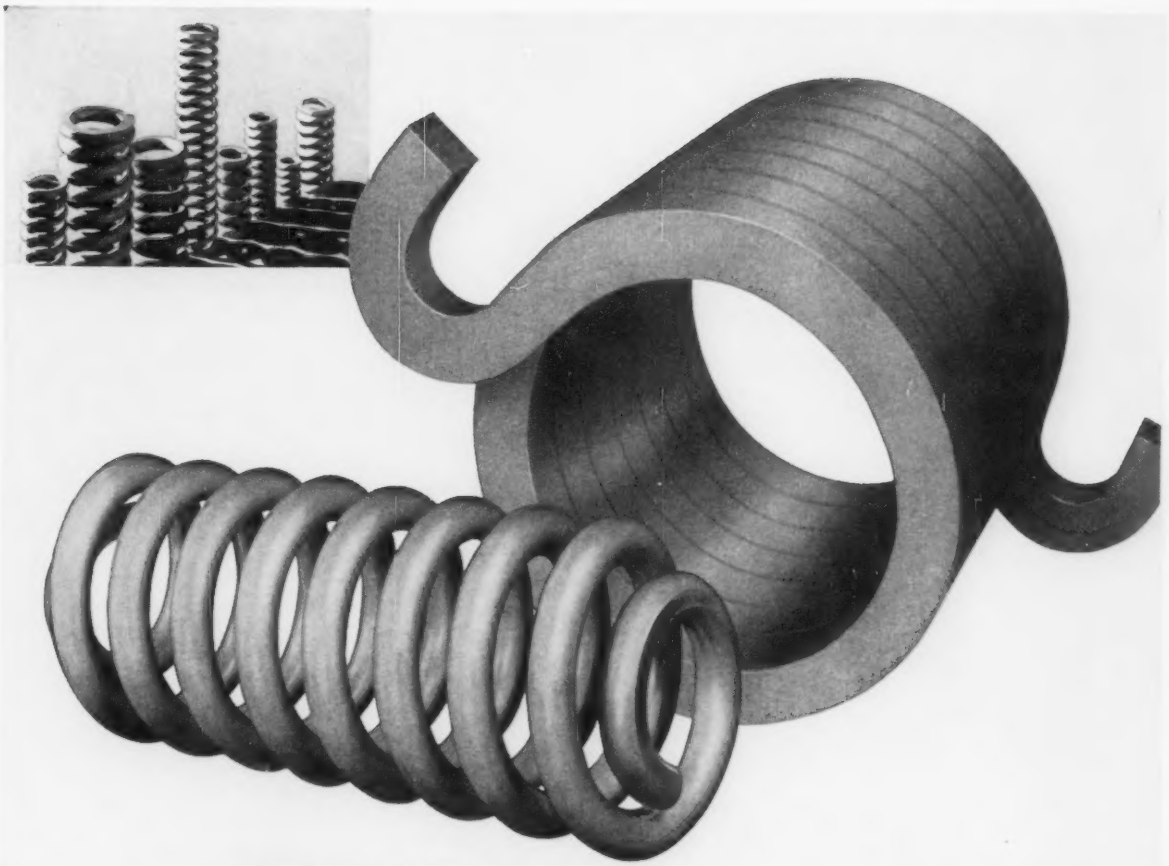
*Our new 8-page brochure "***MODERN MOTORS FOR MODERN-DAY PRODUCTS***" will be helpful in your work. Please write for your free copy.*

REULAND RE® **MOTORS**

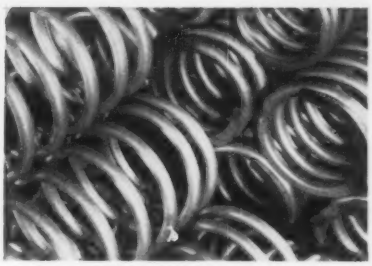
REULAND ELECTRIC COMPANY

Western Division: Alhambra, California • Eastern Division: Howell, Michigan
Distributors in all principal cities

Circle 471 on Page 19



CRUCIBLE FATIGUE-RESISTANT SPRINGS



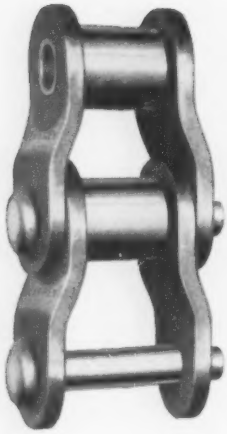
"made stronger to last longer"

Crucible *fatigue-resistant* springs have far greater durability than ordinary springs. Furthermore, these springs, section for section, can take heavier compressive, tensile or torsional loads than ordinary springs. That's because they're *shot peened*. This process imposes a compressive stress on the spring surfaces that offsets stresses set up in service. It also conditions the surfaces, and eliminates minute stress concentration points which could lead to premature failure in a conventional spring.

Try Crucible *fatigue-resistant springs* for lighter springs of improved design, greater precision and longer service life. For complete details, send for the Crucible "Coil Spring Design" handbook. Ask a Crucible spring specialist to call, too. Write: *Spring Division, Crucible Steel Company of America, McCandless Avenue, Pittsburgh 1, Pa.*

CRUCIBLE **HEAVY-DUTY COIL SPRINGS**

Circle 472 on Page 19



Steel Thimble Roller Chain—If you are driving a mixing drum or other equipment at an inclined angle, you can cut wear on chain drive by using this Jeffrey "offset" STR type.

Don't let work-horse appearance fool you . . . chain is a *precision* product. Its tensile strength, fatigue limit and resistance to wear affect the performance and life of *the equipment you make.*

Jeffrey chain is engineered to provide maximum strength with minimum weight, but with ample reserve strength to withstand sudden and heavy overloads.

Jeffrey chain makes good products better!

STR Hollow Pin Chain conveys bread through bakery ovens on smooth-running rollers. Conveniently spaced hollow pins provide an easy method for attaching trays or other fixtures.

Steel Knuckle Chain—Movable packer plate inside this cylindrical refuse truck is operated by using Jeffrey chain as a tension element and driving chain from the truck power takeoff.

Jeffrey engineers will help you design for most efficient use of power and longer lasting power transmission and conveying assemblies.

Here are some of the many types of equipment for which Jeffrey chain has been specified:

- Bakery equipment
- Bottling machinery
- Chemical processing
- Coal washers and jigs
- Conveying, loading, unloading and piling machinery
- Concrete mixers and pavers
- Cranes and shovels
- Earth and rock drilling units
- Elevating graders
- Excavators and trenchers
- Farm machinery
- Food machinery
- Glass batching
- Ice making units
- Industrial ovens
- Lumber and sawmill machinery
- Mining machines
- Pickling and plating machines
- Portable gravel plants
- Refuse collection trucks
- Road rollers
- Steel mill machinery
- Units for washing and drying materials

The Jeffrey Manufacturing Company, 798 North Fourth St., Columbus 16, Ohio.

CONVEYING • PROCESSING • MINING EQUIPMENT...
TRANSMISSION MACHINERY...CONTRACT MANUFACTURING

JEFFREY

Strength

that comes only from forging and rolling

Strength is the first requirement of any crane wheel. Nothing else counts quite so much. This wheel has it.

The wheel was machined from a Bethlehem forged-and-rolled blank—a unique type of blank that is strong all over, and all the way through.

Bethlehem's forging-and-rolling method produces blanks with excellent grain flow and freedom from porosity. The metal down inside, as well as on the surface, is of uniform quality. This makes the machinist's job easier; he can work with confidence. The blanks can be turned, bored, faced, and hobbed with complete assurance of a good finished product.

You can obtain Bethlehem forged-and-rolled blanks in a wide range of sections, and in sizes from 10 to 46 in. OD. Use them when making crane wheels, gears, flywheels, pipe flanges, turbine rotors, sheave wheels, and similar items. Prices are competitive.

BETHLEHEM STEEL COMPANY, BETHLEHEM, PA.

On the Pacific Coast Bethlehem products are sold by Bethlehem Pacific Coast Steel Corporation
Export Distributor: Bethlehem Steel Export Corporation

BETHLEHEM STEEL

BETHLEHEM STEEL

Circle 474 on Page 19

Your First Step

IN MASTERING COSTLY LEAKAGE AND ASSEMBLY PROBLEMS **STARTS AT...**

WEATHERHEAD

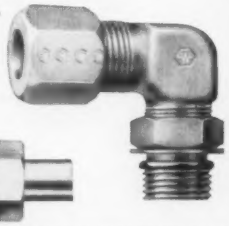
ERMETO Hydraulic Tube Fittings

Most dependable high pressure fitting in the world . . . easiest installation.

FOR FLARELESS TUBE SYSTEMS

No Flaring
No Threading
No Welding
No Soldering

Carbon Steel
Stainless Steel
Cadmium Plated
Weathercoted



Standard Sizes: ⅛" Through 2". Pressure Ratings: 2700 p.s.i. to 10,000 p.s.i. depending on O. D. of tube.

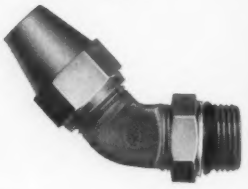
FLARE-TWIN Hydraulic Tube Fittings

SAE 37° FLARE (J.I.C.) STEEL
FOR FLARE TUBE SYSTEMS

3-Piece Type

2-Piece Type

No Threading
No Welding
No Soldering
Carbon Steel
Stainless Steel
Cadmium Plated
Weathercoted



Standard Sizes: ⅛" through 2". Pressure Ratings: 2500 p.s.i. to 10,000 p.s.i. depending on O. D. of tube.

HOSE ASSEMBLIES

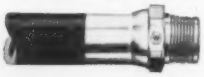
With Reusable Hose Ends

Steel

"D" Style H-69

Clamp-Type

With Permanently Attached Hose Ends



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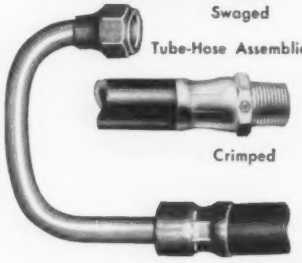
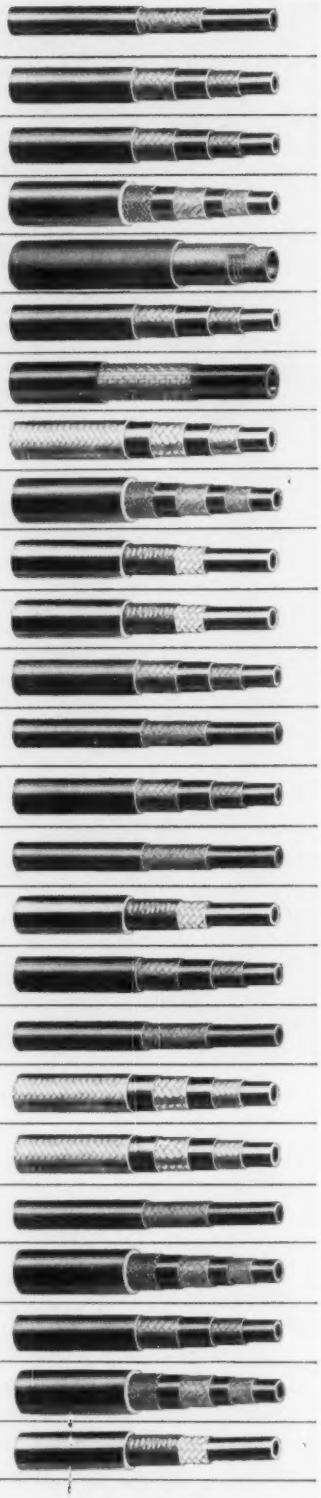


Tube-Hose Assemblies

Crimped

Hose assemblies, hose and hose ends, both permanently attached and reusable to meet any O.E.M. requirement. That's what Weatherhead offers you. Permits unlimited design possibilities.

BULK HOSE FROM 1/8" TO 2 1/2" I. D.; PRESSURES TO 10,000 P.S.I.



and many others

WEATHERHEAD

THE WEATHERHEAD CO. FORT WAYNE DIVISION
Dept. AB-10, 128 W. Washington Blvd., Fort Wayne, Ind.
In Canada: The Weatherhead Co., Ltd., St. Thomas, Ont.

MACHINE DESIGN
October 2, 1958

"...things proper to man."

THERE used to be a theory that it was good for the soul to do at least one unpleasant thing every day. Ours is getting up in the morning. What's yours?

Seriously, though, old-fashioned ideas of discipline and difficulty seem to be yielding to an increasing emphasis on ease and relaxation. "Is everybody happy?" asks Ted Lewis in what has become almost a slogan of the times.

Schools long ago abolished corporal punishment, thus removing one fear that could interfere with the children's happiness. Competition took its place as a spur to learning, but now is falling into disrepute with educators — except in the athletic department. Seems that the kids who make poor grades feel inferior and become unhappy.

Unhappiness is an occupational hazard even in engineering departments, surveys tell us. Supervisors have an irritating habit of assigning to engineers the jobs that the company wants done, rather than the sort of jobs the engineers themselves would like to do. That kind of thing can raise havoc with a person's happiness.

But there's a glimmer of hope that engineering is becoming a happier procedure. Benson-Lehner's delightful spoof, *Engineersmanship*, recommends: "Play cerebral popcorn—be sure to study brainstorming seriously. This is an exciting new game and is wild for the kiddies. Logic is for the stuffed shirts and Aristotle. Why work when it's so easy to have fun and get paid for it?"

Most engineers have enough mental maturity to regard the tougher, less pleasant aspects of their professional life as a challenge rather than a discouragement. Somewhere between the soft, easygoing attitude of a growing segment of our population, and the tough, abrasive approach of a Hyman Rickover — which, by the way, does get things done—there must be an effective middle course (we almost said happy medium).

Let's be happy, by all means. But if we expect to be separated from the boys, let's also remember how Marcus Aurelius, eighteen centuries ago, defined "a man's happiness—to do the things proper to man."

Colin Carmichael

EDITOR

A BIG TOOL FOR BIG JOBS:

How to set up

PROGRAMING

Planning and managing large-scale engineering projects are always tough jobs. During each stage of the project, different people, equipment, and facilities are needed. Therefore, precise integration of carefully timed work contributions is necessary to complete the project on time and within the budget. Programing is a valuable tool for the control job. This article tells what programing is, how to set it up, and how to use it.

DEVELOPMENT and design of large, highly specialized projects present a unique problem for engineering and management. Examples of this type of project are design and production of: 1. A single highly specialized product, such as a reactor-refueling machine. 2. Small lots of complex devices, such as a combination welding and cutting machine. 3. A complete facility, such as a power plant.

Although seemingly different, these examples have several elements in common. They all call for direction of a group effort where the skills of highly trained and specialized people must be organized

Use Programing for All Four Project Phases

Conceptual: Programers help by estimating manpower needs, gathering cost data, planning equipment needs, and helping "prove out" your quotations and estimates. After the contract is awarded, or approval is given, programing lays the groundwork for a smooth start and plans the job ahead.

Formative: There are many separate tasks and subtasks in a large development project. Programing establishes these separate jobs and develops schedules to synchronize their speed. The feedback inherent in programing finds any rough spots in the overall plan or the procedures.

Operational: Once work has begun, programing initiates each separate part of the job at the right time and constantly monitors progress. Any likelihood of missing a schedule is spotted instantly so that management can step in and correct problems. The programing staff is a constant watchdog, finding and reporting on how good the plan was, how well things are going, and how to correct weak spots.

Terminal: Shutting off a large project requires as much control as starting it did. During the mop-up stages, manpower can be wasted, costs can get out of line, delays can occur, and the entire time schedule and budget can be exceeded. Precise control of hundreds of details is needed; this is the job for programing.

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FOR COMPLEX PROJECTS

and integrated to produce the desired result in a specified time. Also, the financial aspects of the project must be carefully administered.

Organizing and planning for large projects is a dynamic process requiring continuous and close measurement and revision. Programing as a staff function has definite value for management in helping meet these needs. The programing staff assists management in planning, measuring output against plans, and replanning as shown in Fig. 1.

Programing a Project: Programing is a basic tool of management for gathering, integrating, and interpreting available information in the areas of objectives, manpower and materials, costs, time, and control. The details of how programing handles these areas are given separately. Supplied with a continuous flow of integrated information on these basic elements, management is able to function more effectively in planning what to do, planning how to do it, planning when to do it, measuring performance against planning, and improving plans and procedures on the basis of analyses and measurements.

Major processes in the programing cycle can be amplified best by following the programing for a

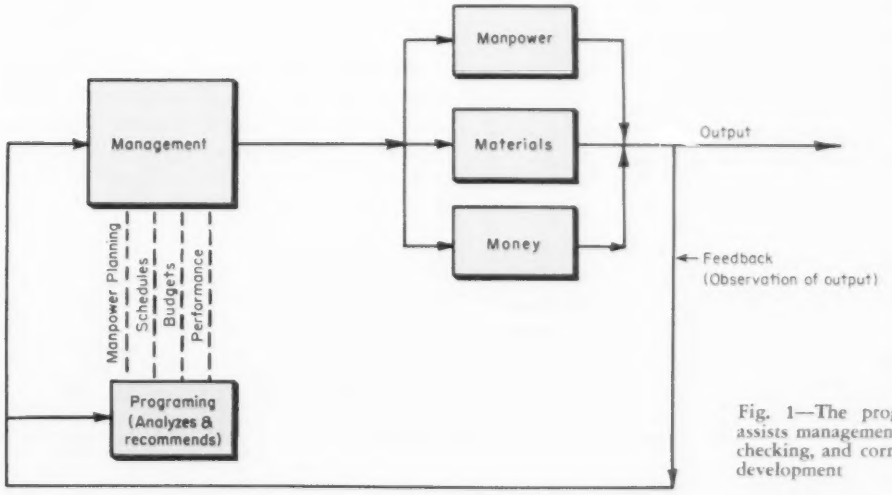


Fig. 1—The programing staff assists management in planning, checking, and correcting project development

specific project and observing each step of the programing process. Programing for a development, design, and production project follows in some detail. Procedures are typical of programing for any project. A typical project-oriented organization is shown in Fig. 2, and the programing staff is related to one particular project organization as depicted in Fig. 3. The organization, like other aspects of a project, changes with time. Most projects, in fact, go through four phases:

1. Conceptual phase.
2. Formative phase.
3. Operational phase.
4. Terminal phase.

Programing in the Conceptual Phase: A project is first conceived when a customer or potential customer states his requirements in general terms. The interested company responds by finding out as much as possible about the customer's objectives, and then prepares a proposal. The project is next initiated, usually by establishing broad objectives and by appointing a project manager.

At this point, the project will develop in either of two ways. In one case, a small study team of senior engineers may make feasibility studies of various conceptual designs. With such a small group, this preliminary work can run from about 6 months to 2 years, depending on the size of the project. In the other case, the project may be staffed rapidly to near-peak strength. The personnel are first grouped into study teams, each to develop and/or evaluate the feasibility of a concept.

In this conceptual phase, the technical-programing group plays a big part. Programers weave reasonable schedules from skimpy assumptions, supply data to assist making sound manpower estimates, evaluate costs and equipment requirements, and see that these parts of the proposal are consistent and convincing.

If the customer accepts the proposal and a contract is obtained, the conceptual phase of the project continues for a while longer. During this period, conceptual engineering-design work is carried on. Concurrent with conceptual design, the programing groups prepare a preliminary list of tasks—specific work "packages". After the Preliminary Task List is evolved, a brief description of the scope of the work and the specific goals for each task is prepared, Fig. 4. This form shows that preliminary manpower requirements and cost estimates are developed at this time.

What Programing Can Do

The job of gathering, integrating, and interpreting information from many areas is the main purpose of the programing staff. For engineering-project purposes, programing correlates data in five major areas:

Project objectives: Programing is concerned with assisting management in attaining the specific technical, cost, time, and manpower objectives of the project within the framework already established by management.

Manpower and materials: Efficient utilization of manpower is of major importance in a project where many highly skilled people are employed. The programing staff can aid in preparing and integrating manpower projections and in preparing related records used for control and measurement.

Costs: Of course, costs are of vital importance in any business. Details concerning management-established project objectives, and the manpower and hardware requirements, form the basis for far more accurate budgeting and cost estimation than old rule-of-thumb and experience methods. The programing staff is in an excellent position to correlate the historical data and analyses of the accounting group with project objectives and growth. With this information, management can prepare more accurate budgets and forecasts.

Time: This basic element of programing is expressed by time schedules. The master schedule shows the time objective for each major task. The detailed schedules show the time cycles required to accomplish each step of the project plan. The element of time must be tied closely to manpower requirements and budgets and to engineering development and delivery of hardware.

Measurement and Control: Management must be provided with up-to-date information about actual performance versus planned progress. Thus, programing assist management with measurement and control.

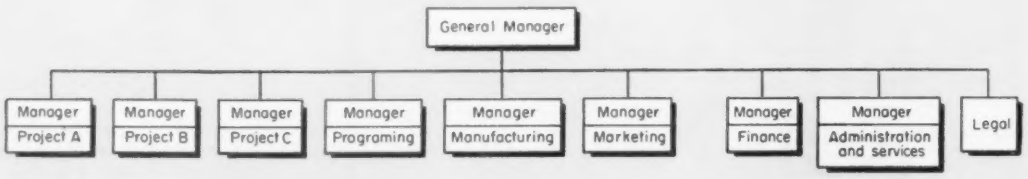


Fig. 2—This organization chart shows how a firm can be set up to handle large, special projects

Programing in the Formative Phase: When the conceptual design is developed, the project begins to take shape and enters the formative phase. Programing in this phase aids in firmly establishing the major tasks. These tasks can be divided further into subtasks for easier planning and following. The programers, working with the engineers, plan the major steps or "milestones" for completion of the tasks, Fig. 5. Each item must be examined carefully to determine its effect on other related items with respect to initiation and completion.

Detailed schedules are next made up for each milestone in each subtask, Fig. 6. If there are any conflicts in the over-all Milestone Chart, this final detailing will expose them. These detailed schedules are important for both control and measurement purposes.

As it becomes necessary, detailed schedules are revised so that people working from them will be assigned to jobs in proper sequence. Typical detailed steps leading up to a normal first milestone, "Design Specifications, Customer-Approved," are:

1. Complete preliminary investigation.
2. Evaluate data and establish design direction.
3. Prepare specification and request quotations for development unit.
4. Order development unit.
5. Fabricate and test the development unit.
6. Evaluate test data and establish design requirements for production units.
7. Prepare specification for production units.
8. Obtain internal specification comments.
9. Complete specification and submit to customer for approval.
10. Receive customer approval of specification.

As soon as feasible, a bill of materials is prepared, listing each system and its components and the quantity required. The responsible organization may also be shown. The bill of materials is kept up to date as the project progresses and is used as a control for placement of orders.

Three major problems that arise in project organization are: 1. Achieving buildup of manpower as the project starts to accelerate. 2. Obtaining personnel with the required specialized training and experience. 3. Redistributing people to other projects

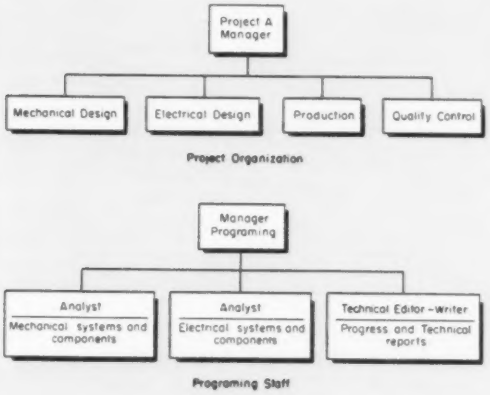


Fig. 3—Command organization for an engineering project and programing-staff organization for the project must be adapted to the project's size and complexity

Fig. 4—Preliminary Task List serves as the project plan and gives preliminary manpower and cost estimates

Milestone Program
Subtask 6.1 Control Mechanism
Milestone
Date
1. Issue application specification.
2. Complete component evaluation tests to establish design.
3. Issue firm equipment specification for prototype and mechanism to customer for approval.
4. Place order for prototype mechanism and final mechanism.
5. Order materials for prototype mechanism.
6. Release manufacture of prototype mechanism.
7. Perform acceptance tests on prototype mechanism.
8. Order long-delivery materials for production mechanism.
9. Start manufacture of production mechanism.
10. Start acceptance tests of production mechanism.
11. Deliver production mechanism.

Fig. 5—Milestone Program for one subtask of a major development project shows how programing breaks a large project down into easily managed segments

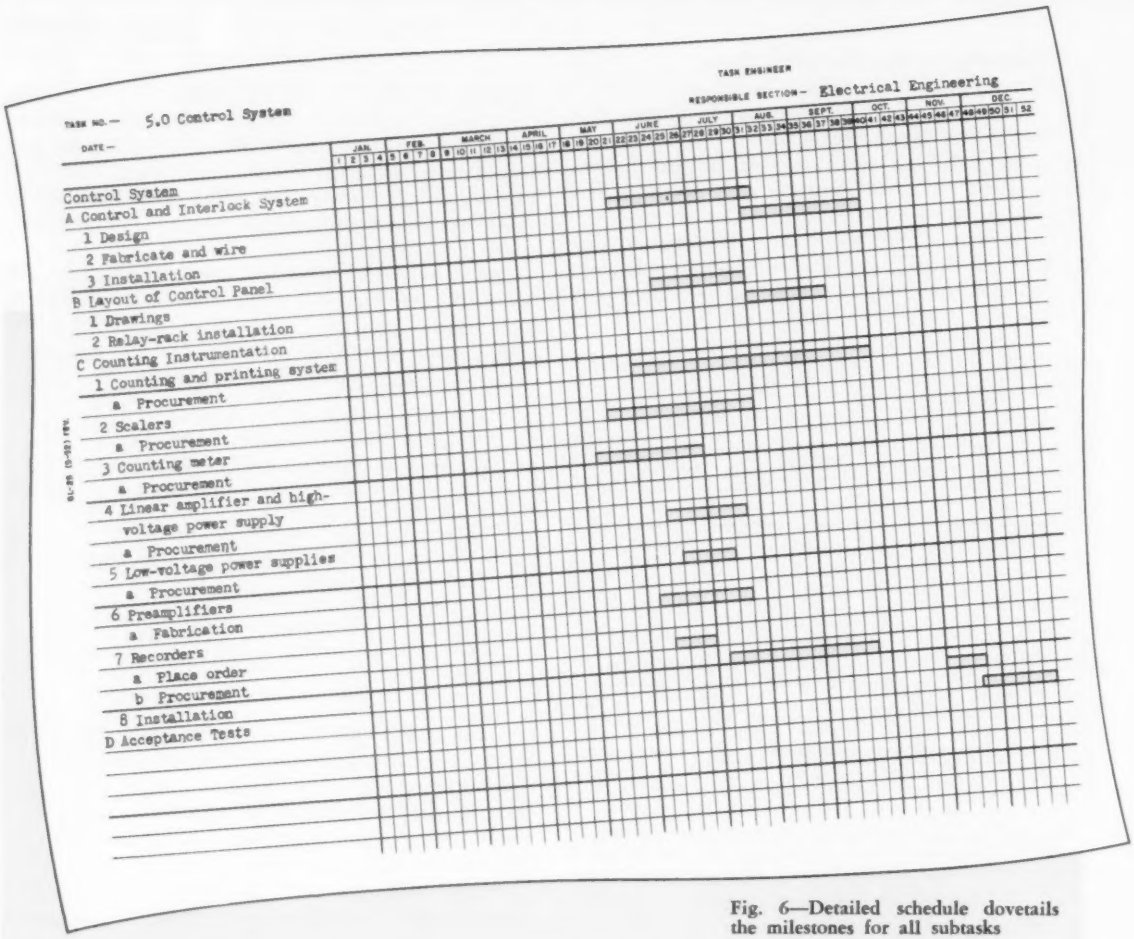


Fig. 6—Detailed schedule dovetails the milestones for all subtasks

as the project tapers off. The programing staff, by integrating all available information and preparing short and long-range forecasts, helps management deal with these problems more effectively.

Budgeting and cost control are important for any profit-motivated enterprise. Programing relates costs to tasks, manpower, and time. The milestones and milestone dates are worked out by the programing staff in discussion with the task leaders. Next, the manpower and material required to accomplish each milestone are estimated by the engineer. Programers and engineers then develop the manpower and material required each quarter, or even each month, for each task and for the entire project. This information is then used to calculate the funds required for such a program.

At this stage, the complete program for the project has been worked out in some detail. This program must now be reviewed by the programing staff and by the engineers by asking questions such as:

1. Are the milestones and milestone dates for the different tasks consistent and tight—but not too tight?
2. Is the manpower buildup by numbers and types of personnel reasonable and possible?
3. Are the costs of the tasks and over-all program reasonable and economical enough to accomplish the objectives?

When the program is reviewed in such a critical manner, some changes are usually required. Programing then has the function of continuously monitoring in this critical manner throughout the life of the project.

Because the programing staff must maintain an intimate knowledge of all work of the project, it is desirable to include the project reporting and project procedures functions within this group. Although periodic and special reports of progress on each task must be written by the responsible engineers, the programing group can integrate these into a consistent report, prepare summaries for management, and edit and handle publication of the project reports.

For the same reasons, the programing organization is in the best position to detect procedural problems and prepare, for management approval, procedures for efficient and consistent project operations. This is no small task in practice, since many procedures must be prepared early in the project and should serve as long as possible. Although procedures are continually changed throughout the life of the project, each change or new procedure usually produces a temporary faltering in some operation. It is therefore desirable to keep new procedures to a minimum and to depend upon the previous ex-

Machine Design, Construction, and Installation

Weighted Percentage-Complete Report

	Goals	Cumulative Per cent Complete
1.	Establish conceptual design of machine	15
2.	Obtain customer approval of conceptual design	16
3.	Develop new or specialized mechanical components	26
4.	Develop new or specialized electrical components	31
5.	Build prototypes and breadboard models of new or specialized components	--
6.	Complete test facilities	--
7.	Complete tests of prototypes and breadboard models	--
8.	Initiate procurement of long lead items	--
9.	Complete production drawings and obtain approval as required	--
10.	Complete material ordering	--
11.	Complete machine assembly	--
12.	Complete performance tests	--
13.	Ship machine and instruction books	--
14.	Supervise installation of lead machine	--

Fig. 7—Weighted Percentage-Complete Report serves as a monthly check of finished work for comparison with schedule

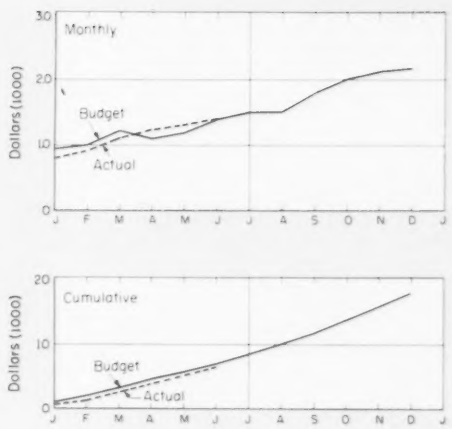


Fig. 8—Monthly actual costs must be compared with the budget frequently to quickly detect irregularities

perience of the programing group to maintain good continuity with previously satisfactory procedures.

Programing in the Operational Phase: A leveling off of the number of people on the project is a characteristic of the operational phase. The program is then fairly well stabilized with respect to objectives, milestones, and detailed schedules.

During the operational phase the prime function of the programing staff is to provide the tools of measurement to the project manager. Programers follow all details of the project—design, fabrication, construction, costs, and schedules; they report variances and the effects of such variances immediately to management. By proper use of programing, the project manager is able to take preventive or corrective action before the damage becomes serious.

Thus, programing provides more than a light for the path ahead. Programing provides a measure of how closely the path has been and is being followed and to what degree goals have been attained. Programing answers such questions as:

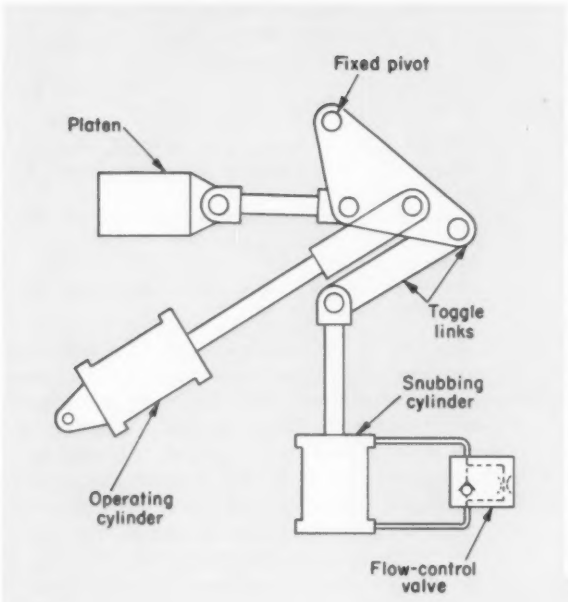
1. Were functions, tasks, and components well organized?
2. Are the number and kinds of people available when needed?
3. Was the original schedule reasonable or was performance poor as measured by a good schedule?
4. What critical items jeopardize the entire schedule at any given time?
5. Is there failure in meeting milestone dates in one particular area, and if so, why?
6. Were cost estimates good?
7. Are costs within the budget, and if not, which tasks are running in excess?

In addition to the charts discussed for planning, supplementary charts and reports are used for measuring and controlling. The Critical-Items Report, a weekly report on items seriously affecting the over-all schedule, may be employed. Another valuable report is the Weighted Percentage-Complete Report, Fig. 7. Monthly costs versus budgeted costs, and cumulative costs versus budgeted cumulative costs for each task are extremely valuable, Fig. 8. A breakdown of indirect costs and a comparison of indirect expense with the applied rate can also be made a part of the programing activity. This does not imply that programing takes over accounting functions, but rather that from prompt, well-planned accounting reports, programers can analyze, evaluate, and prepare reports for management.

Programing in the Terminal Phase: This phase of a project requires, perhaps, the most careful or finest planning by the programing staff. Design engineering drops off rapidly, construction proceeds at peak rate until it is completed, and the mix of types of expenditures changes rapidly. It is at this time that bottlenecks or "bugs" may occur which necessitate increased efforts. The programing group must follow schedules, procurement, and construction especially close to anticipate problems far enough in advance to permit forstalling them.

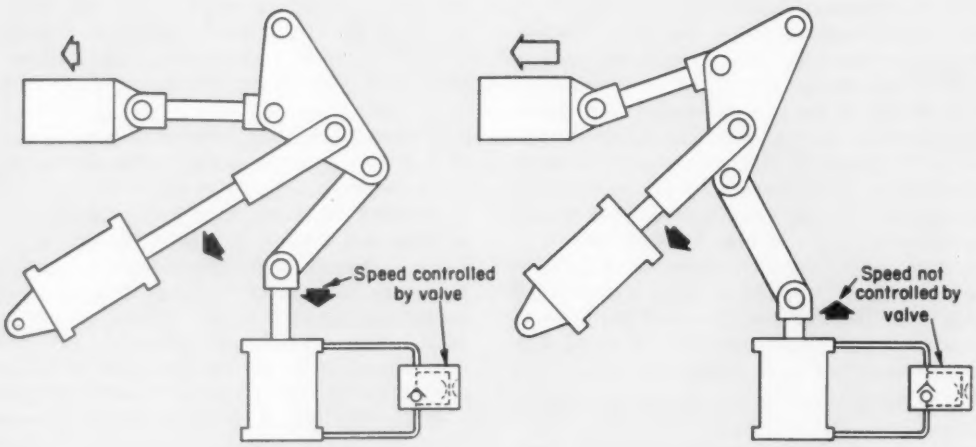
When the project is completed, programers review the entire project performance, prepare an analysis of variances from plans, and make recommendations for succeeding projects.

scanning the field for *ideas*

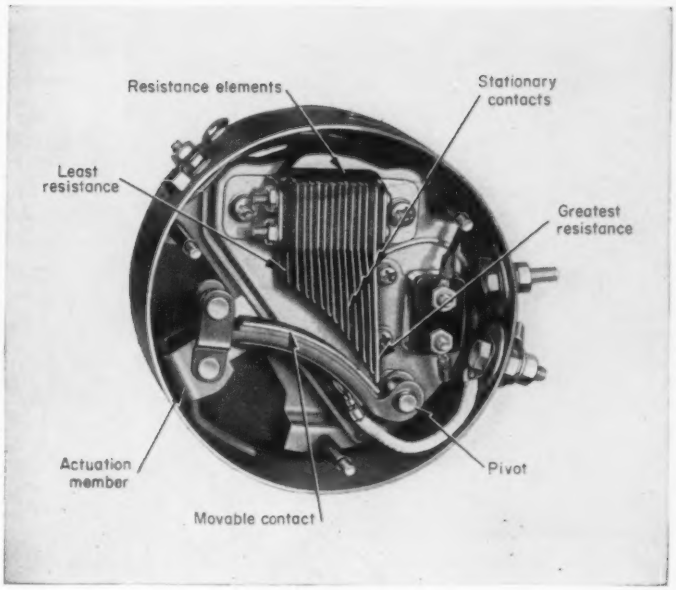


Two-speed motion is provided for a hydraulic-actuated moving platen by a simple toggle linkage and a hydraulic snubber. For part of the platen travel, movement is controlled by the snubber; for the following part of the movement, full cylinder speed and pressure are applied.

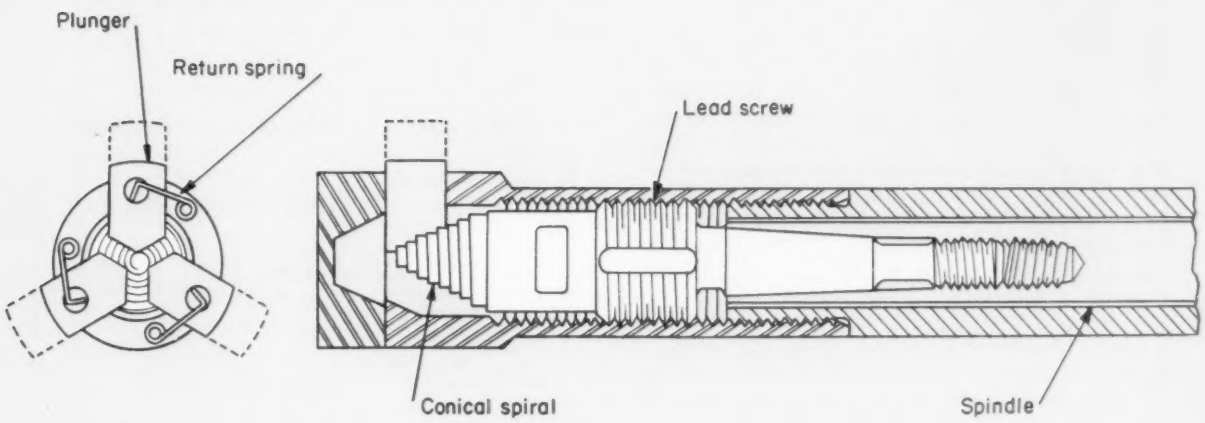
When the cycle starts, the operating cylinder pulls the toggle toward the straight position, advancing the platen, and forcing exhaust from the snubbing piston through a flow-control valve. As the toggle linkage passes the straight position, the snubbing-cylinder piston begins to rise, the snubbing action is bypassed, and full operating-cylinder pressure is applied to the platen. On the reverse stroke, a check valve permits bypass of the snubbing cylinder to provide fast retraction. The mechanism is employed by Thomson Electric Welder Co. on the Synchro-Matic welder.



Programmed contact closing for consecutive circuits with decreasing resistance produces a gradual transition from no current flow to full current. A moving contact arm swings into a bundle of stationary contacts of decreasing length, each of which has less resistance than, and serves to bypass, the preceding, longer one. Current flow is thus readily controlled by the amount of movement of the moving contact. The design was developed for a rheostat application by Warner Electric Brake and Clutch Co.



3-D spiral expander achieves equalized outward movement of radial sliding members with a high degree of precision. The conical spiral is machined at the end of a spindle that is rotated and advances axially because of its lead-screw construction. Pitch of the lead screw and spiral are equal, so the conical spiral maintains uniform contact with the sliding members and forces them outward at a uniform rate during rotation of the spindle. Developed by Brown & Sharpe Mfg. Co. for an internal micrometer, the design offers sufficient accuracy for diameter readings to 0.0001 in.



Lost motion in

PRECISION

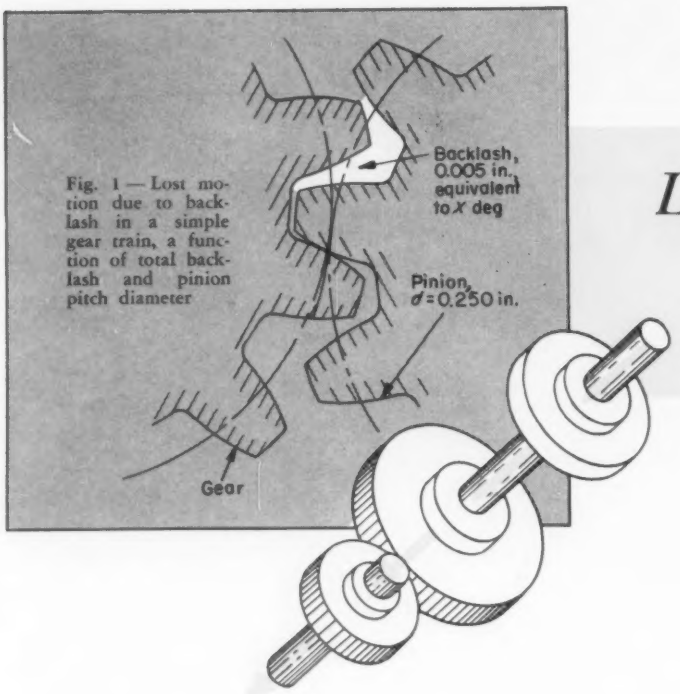


Fig. 1 — Lost motion due to backlash in a simple gear train, a function of total backlash and pinion pitch diameter

If accuracy is to be obtained from mechanical control systems, precision must be designed into the gear arrangement. Play or backlash in the gear train must be minimized, requiring a careful study of lost motion. Here, in two parts, is a practical treatment of lost motion and how to circumvent it. In this first part, the inherent causes of backlash are covered, while part two will discuss the dynamic aspects of the problem.

LOST motion in a precision gear train becomes extremely important when the output is used to position a control device such as a potentiometer, synchro, variable condenser, or lead screw.

If the input motor is able to produce shaft rotation through an appreciable number of degrees before the output shaft starts to turn, a hunting condition will exist at the input, and accurate positioning control of the output is lost. This backlash, or free movement in the gear system, is of two origins—designed or induced.

Design Backlash: Play between the mating teeth of two gears is defined as pure backlash, and is the distance, measured along the pitch circle, through which a gear tooth can be moved within the mating tooth space. It may be expressed as a linear measurement in inches, or as an arc in degrees or radians.

Backlash, in some amount, is designed into gear teeth for two reasons: 1. To insure that two gears will rotate without binding when meshed at design center distance, even though both gears contain some runout. 2. To provide a manufacturing tolerance in cutting the teeth.

In simple gear trains, the lost motion, expressed in degrees of pinion rotation with the output gear clamped, is a function of the pinion pitch diameter and the total backlash in all meshes. The lost motion is equivalent to x deg of arc, Fig. 1, measured on the pitch circle of the pinion. The value of pinion rotation x is $x/B = 360/\pi d$ (see Nomenclature), from which,

$$x = \frac{360}{\pi}\left(\frac{0.005}{0.250}\right) = 2.29 \text{ deg}$$

Since the term $360/\pi$ is a constant equal to 114.59 deg, the following general expression for pinion rotation can be written:

$$x = 114.59\,\frac{B}{d} \qquad (1)$$

Thus, pinion rotation becomes greater as backlash is increased, or as pinion pitch diameter is decreased.

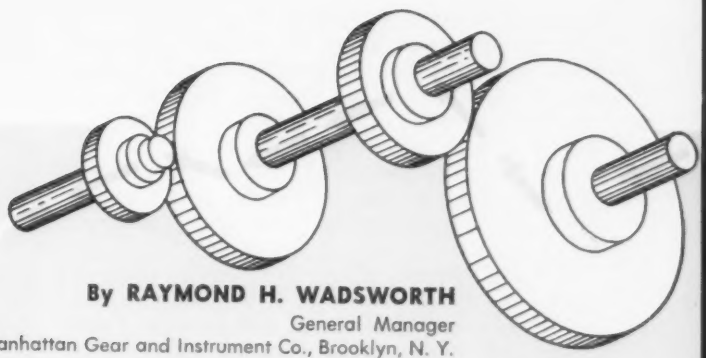
In place of Equation 1, the chart explained in Example 1 can be used to find the lost motion due

Nomenclature

B = Backlash, in.
ΔB = Change in backlash, in.
C = Center distance, in.
ΔC = Change in center distance, in.
D = Pitch diameter of gear, in.
d = Pitch diameter of pinion, in.
P = Diametral pitch
x = Pinion rotation, deg
ϕ = Pressure angle, deg

Part 1

GEAR TRAINS



By RAYMOND H. WADSWORTH
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Example 1

In Fig. 1.1 a simple gear train is shown, which consists of an input or drive pinion with a pitch diameter of 0.25 in., an idler, and an output gear. To determine the lost motion of the system in terms of the rotation of the drive pinion, the output gear is assumed to be clamped.

Solution: Since the specified backlash between the drive pinion and idler is 0.001 in., and the backlash between idler and output gear is 0.002 in., the total backlash for train is 0.003 in.

The rotation, x, can be found from Fig. 1.2 by entering the chart at the value of the total backlash in the system, 0.003 in. The vertical projection of the point of intersection of the backlash line with the diagonal line indicating the proper pitch diameter, 0.25, gives the pinion rotation, 1.38 deg.

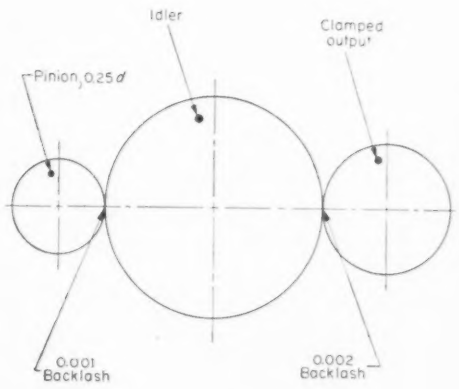


Fig. 1.1—Simple gear train with backlash

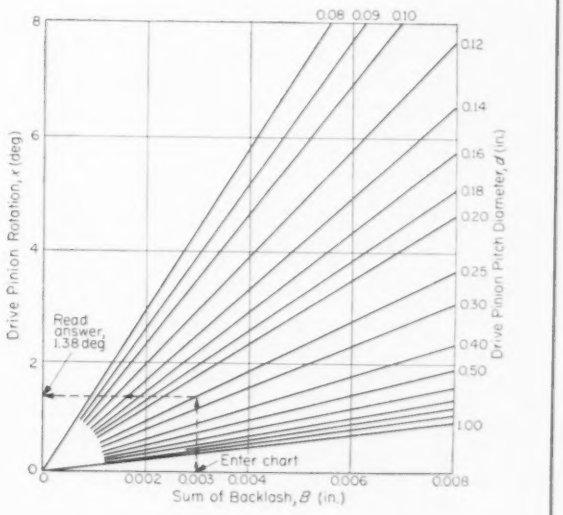


Fig. 1.2—Lost motion in simple gear train

to pure backlash in any simple gear train.

In compound-gear trains, the method of analysis differs from that used in simple gear trains. Using the data given, Fig. 2, a mathematical statement similar to Equation 1 may be set up for the lost motion at the pinion when the output gear is clamped. In the analysis of compound-gear trains it is convenient to refer to the last, or the output mesh, as the nth mesh, and then name each preceding mesh $n - 1$, $n - 2$, and so on.

First the accumulated backlash from the clamped output gear, G_4, back through the train to the $n - 1$ mesh can be computed, and Equation 1 can be applied. Since the backlash at nth mesh is given, the backlash appearing on G_2, due to compound ratio of pitch diameters, is $(0.001)(1.500)/(0.300)$, or 0.005 in. The total accumulated backlash at $n - 1$ mesh then becomes the sum of that

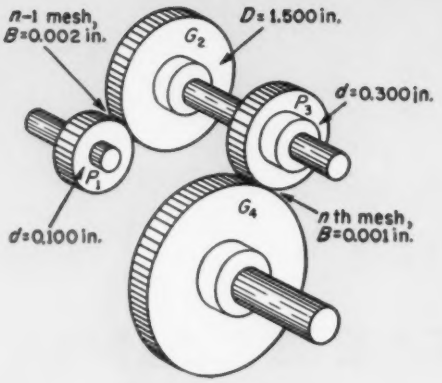


Fig. 2—Lost motion in a compound gear train due to pure backlash, which depends on the backlash between meshes, pitch diameter of pinion, and compound ratio

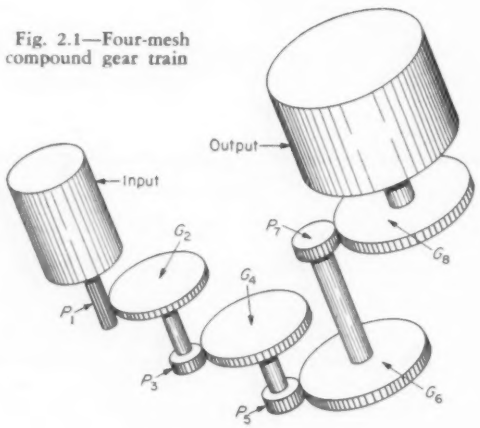


Fig. 2.1—Four-mesh compound gear train

Example 2

Fig. 2.1 shows a four-mesh, compound-gear system for which the lost motion must be found. The backlash at each of the four meshes is 0.0004 in. Pitch diameters, mesh numbers, and compound ratios are:

Gear or Pinion	Pitch Diameter (in.)	Mesh Number	Compound Ratio
P_1	0.100	$n-3$	
G_2	1.000		5:1
P_3	0.200	$n-2$	
G_4	1.200		4.8:1
P_5	0.250	$n-1$	
G_6	1.500		5:1
P_7	0.300	n	
G_8	1.800		

Solution: If all meshes have zero backlash except the

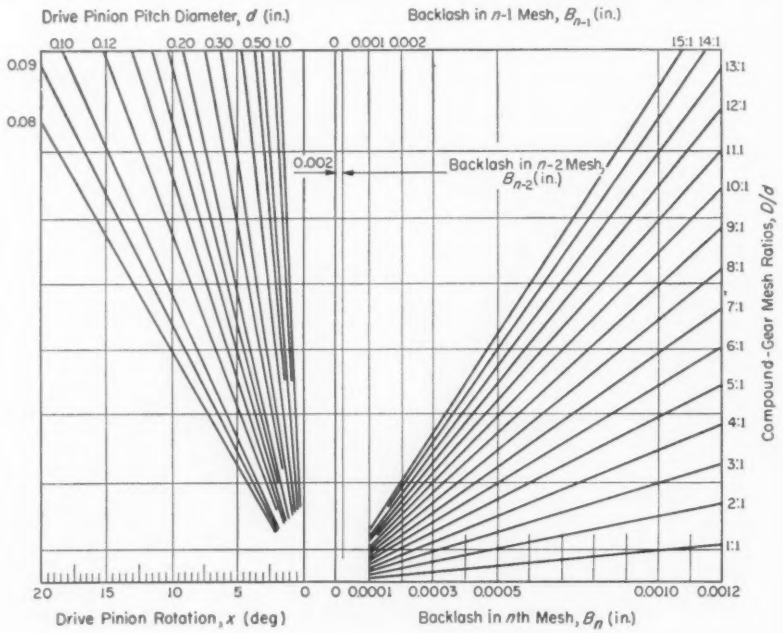


Fig. 2.2—Chart for determining pinion rotation in compound train. For correct value, multiply answer from chart by 10^{n-2}. Zero backlash may be assumed for all meshes beyond $n - 2$

appearing on G_2, and that given for the $n - 1$ mesh. This total is 0.005 + 0.002, or 0.007 in. Substituting in Equation 1, the lost motion at the pinion is

$$x = 114.59 \left(\frac{0.007}{0.100} \right) = 8.02 \text{ deg}$$

There is one word of caution in the solution of compound gear problems. When simple meshes are considered, it is customary to define the gear ratio as the number of teeth in the driven gear divided by the number of teeth in the drive pinion. When a compound-gear mesh is required, the actual pitch diameters of the compounded pair, not the number of teeth, should be used. This is necessary because both members of the compound pair do not always have the same diametral pitch hence, although the number of teeth in each gear might be identical, the actual pitch diameters may differ.

A complete analysis of a four-mesh compound gear train by equation and by use of chart are given in Example 2.

Gear Quality: In using the term gear quality, only the attributes of the individual finished gear are considered. It is assumed that quality factors such as surface finish, material, and dimensional requirements can be met. The important quality considerations are the total composite error, TCE, and the tooth-to-tooth composite error, TTCE. These values control the runout of the pitch diameter with the bore. It is significant to note that backlash is not a matter of gear quality, since the finest pre-

mesh being analyzed, the effect of the backlash at that particular mesh, reflected back to the pinion, will be the product of the given backlash and all the preceding compound ratios. The computation is shown here in tabular form, where lost motion at P_1 is the product of the referred backlash and the Equation 1 constant, $114.59/d_{P1}$.

Mesh Number	Backlash Referred to P_1 (in.)	Equation 1 Constant	Lost Motion at P_1 (deg)	Lost Motion at P_1 (% of total)
$n-3$	0.0004	114.59/0.100	0.46	0.7
$n-2$	(0.0004)(5)=0.0020	114.59/0.100	2.29	3.3
$n-1$	(0.0004)(4.8)(5)=0.0096	114.59/0.100	11.80	16.0
n	(0.0004)(5)(4.8)(5)=0.0480	114.59/0.100	55.00	80.0
	Total Lost Motion		68.75	100.0

From this analysis, it is possible to draw the following conclusions. First, since the greatest lost motion at the pinion is due to the backlash at the output mesh, it is desirable to design for minimum backlash at this last mesh. In practice, it is necessary that the last two gears be precisely cut, with no appreciable eccentricity, so that the backlash can be closely controlled. Second, with only 0.7 per cent of the total backlash attributable to the input mesh, the two gears of the input mesh can be cut to a less precise quality standard than the output pair.

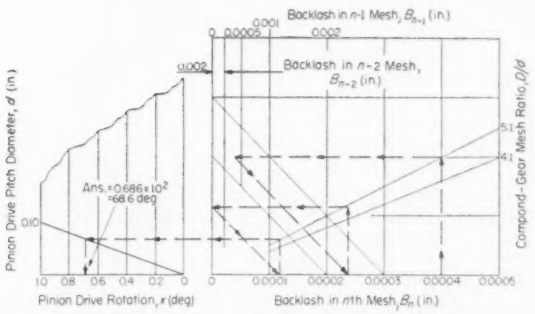


Fig. 2.3—Solution for pinion rotation in compound train

Because the preceding analysis can become tedious and time-consuming in design problems, a chart similar to Fig. 2.2 can be constructed. The four-mesh gear train of Fig. 2.1 is analyzed by using the chart of Fig. 2.3, which is a horizontal expansion of a portion of Fig. 2.2, as follows:

1. Enter the chart at the value of the given nth mesh backlash, 0.0004 in.
2. Proceed vertically to the intersection of the "Compound-Gear Mesh Ratio" for first compounded gear and pinion, $G_6/P_7 = 5{:}1$.
3. Proceed horizontally to the backlash value, 0.0004 in., of the next mesh, $n - 1$, on the "Backlash in $n - 1$ Mesh" scale.
4. Next, move parallel to the diagonal directrix lines to the "Backlash in nth Mesh" scale.
5. Continue through the chart as outlined in 1, 2, and 3, each time using the successive values of the compound ratios and the mesh backlash, until the value for the input mesh backlash is reached.
6. Then move parallel to the directrix lines to the vertical line of zero backlash. Values of backlash are located accurately only through the $n - 2$ mesh. After this mesh value is located, the line of zero backlash is used for successive meshes. This can be seen from the results of the preceding tabular analysis. Hence, for the $n - 3$ mesh in this example, a point on the zero backlash line is used, and a line parallel to the directrix line is not needed.
7. Proceed horizontally to the intersection of the "Pinion Drive Pitch Diameter" line with the proper value, $P_1 = 0.10$ in.
8. Drop vertically to the "Pinion Drive Rotation" scale and extract the value, 0.686 deg.
9. Multiply this value by 10^{n-2} to obtain the approximate answer, 68.6 deg.

When idler gears are used in the system, the value of the backlash used in the table is the sum of the backlash of the two meshes which include the idler. Therefore, Fig. 2.2 can be used for these problems with this one modification.

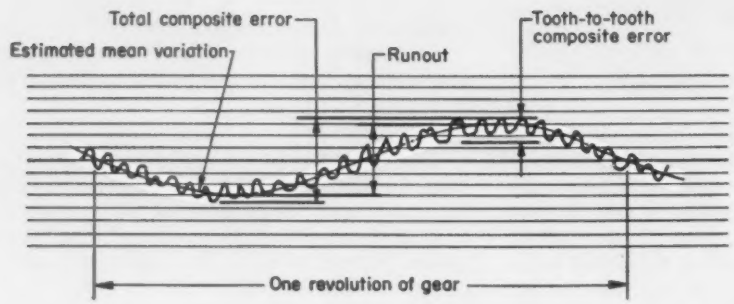


Fig. 3—Runout—the difference between total composite error and tooth-to-tooth composite error

cision gears may be generated with any desired amount of backlash.

The plot of a tooth-by-tooth test on a gear containing generated errors is shown in Fig. 3. This was obtained from the flicker on the indicator of a variable center-distance fixture while the specimen was rotated in intimate contact with a master gear of known accuracy.

ASA and AGMA standard backlash specifications must be met at the tightest point of mesh between mating gears. This means that if a large total composite error is permitted, there will be additional backlash when the gears mate at the low point of runout. The increased backlash at this low point is induced because the teeth at this point actually operate at the equivalent of an increased center distance. This increase in backlash due to the momentary equivalent increase in center distance may be evaluated from

$$\Delta B = \Delta C(2 \tan \phi) \qquad (2)$$

The determination of this induced backlash is

Table 1—ASA and AGMA Tolerances for Fine Pitch Gears

Quality Class	Total Composite Error, TCE (in.)	Tooth-to-Tooth Composite Error, TTCE (in.)
Commercial 1	0.006	0.002
Commercial 2	0.004	0.0015
Commercial 3	0.002	0.001
Commercial 4	0.0015	0.0007
Precision 1	0.001	0.0004
Precision 2	0.0005	0.0003
Precision 3	0.00025	0.0002

Example 3

A pinion with 15 teeth, 120 DP, drives a gear having 225 teeth, in an instrument gear train. Both gears are designed as commercial class 4, and are cut to mate with 0.001 in. backlash at standard center distance. Determine the maximum momentary backlash when the center distance is held to nominal. Pressure angle is taken as 20 deg.

Solution: In this problem it is assumed that both gears are positioned at the point of loosest mesh, and that both contain maximum TCE of 0.0015 in., with 0.0007 in. TTCE. Hence the average runout is 0.0015 − 0.0007 = 0.0008 in.

The total apparent increase in center distance is $\Delta C = 0.0008 + 0.0008 = 0.0016$ in., and from Equation 2,

$$\Delta B = 0.0016(2 \tan \phi) = 0.0012 \text{ in.}$$

Since the original backlash was 0.001 in., the maximum momentary backlash is 0.0022 in.

It must be recognized that although it is improbable that all the conditions contributing to maximum backlash will exist simultaneously, the condition can exist, and the method of analysis should be understood.

Should such a condition occur at a critical time at the nth mesh, the increase in backlash could represent a considerable amount of lost motion at the pinion.

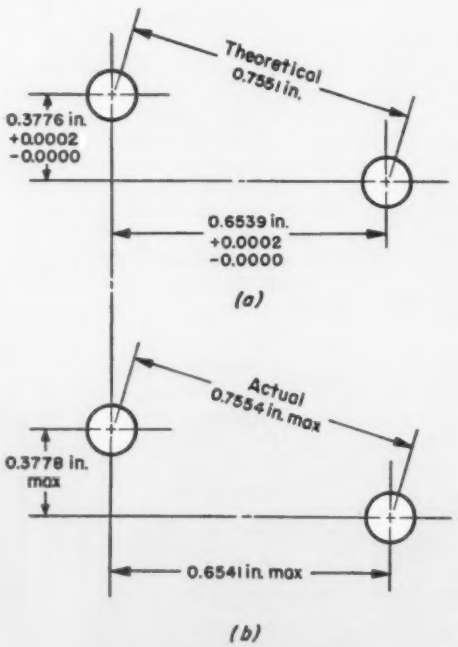


Fig. 4—Effect of jig-boring tolerance on center distance

Example 4

Fig. 4.1 shows a plot of the maximum and minimum permissible gear sizes having maximum TCE, where curve *a* is for the maximum gear size and curve *b* the minimum. The indicator plot assumes a 48-DP, 20-deg pressure-angle gear, cut to AGMA quality classification of precision 1-*A* where *A* signifies the backlash classification as specified in Table 2. Tables 1 and 2 give values, TCE = 0.001 in., TTCE = 0.0004 in., and *B* = 0.003 in. min and 0.005 in. max, for the gear plotted.

In plotting the curves, both the intentional backlash, 0.003 in., and the backlash tolerance, 0.002 in., must be converted to center distance change by the use of Equation 2. Since one-half of the given backlash is usually assigned to each gear, the values obtained from Table 2 should be divided by two when analyzing a single gear. This determination yields backlash tolerances, in terms of ΔC, of 0.0021 in. min and 0.0034 in. max. These values are measured in the minus direction. The value of TCE does not have to be converted, since it is already in terms of ΔC. The important facets of Fig. 4.1 can be analyzed as follows:

1. The maximum zone of acceptability is seen to lie between −0.0021 and −0.0044 in.
2. The value −0.0021 in. is the minimum intentional ΔC caused by a maximum-size acceptable gear when meshed in intimate contact with a master gear or rack. The master and test gear centers may not be farther apart than standard center distance minus 0.0021 in.
3. The value −0.0044 in. is the maximum allowable ΔC caused by a minimum-size acceptable gear. The master and test-gear centers may not be closer together than standard center distance minus 0.0044 in. However, the value 0.0044 in. is reached only when the TCE is a maximum of 0.001 in. In the event that the TCE of gear *b* were reduced to zero, the 0.0044 in. value would become 0.0034 in.
4. Gear c is almost perfect, but it does not satisfy the condition that at least one tooth must touch, or extend above the 0.0034 in. line. It can be seen that although gear *c* does not satisfy the requirements, it should not be rejected if it is employed in an adjustable-mesh system.

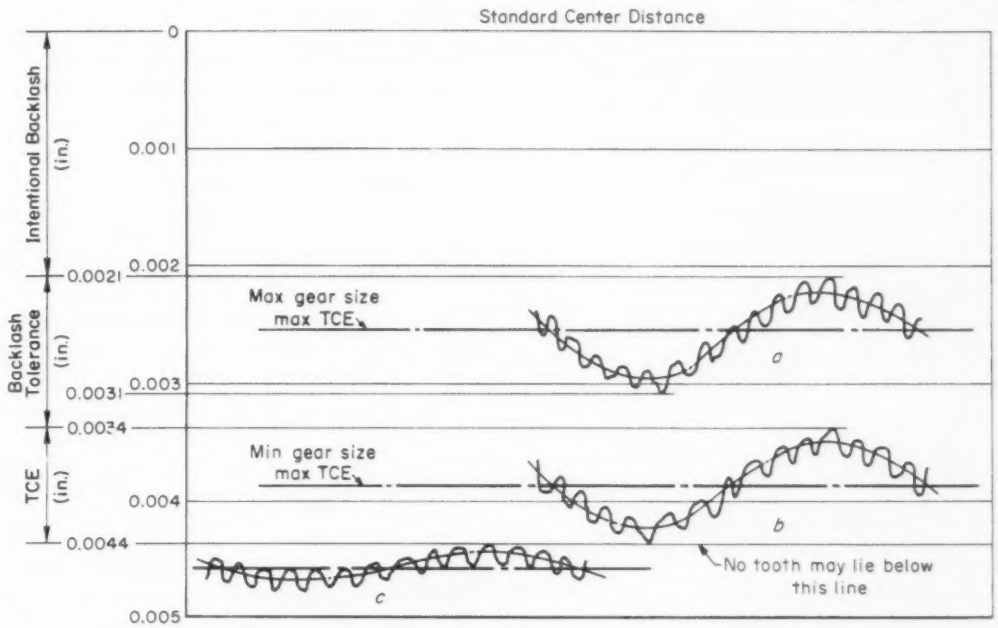


Fig. 4.1—Plot of indicator flicker on three gears: *a* and *b* show limits of acceptability; *c* shows rejected gear, acceptable for adjustable center use

Table 2—Specified Backlash for Various Diametral Pitches

Backlash Classification	Diametral Pitch Range	Backlash in Gears of Equal Tooth Thickness (in.)
A	20–45	0.004–0.006
	46–70	0.003–0.005
	71–90	0.002–0.0036
B	20–60	0.002–0.004
	61–20	0.0015–0.003
	121 and finer	0.001–0.002
C	20–60	0.001–0.002
	61–120	0.0007–0.0015
	121 and finer	0.0005–0.0010
D	No measurable backlash at any pitch	

illlustrated in Example 3, and the ASA and AGMA quality standards* for commercial and precision gears are given in Tables 1 and 2 for convenience.

It is apropos at this point to discuss briefly the subject of finished gear inspection as it pertains to the quality of a gear. Specifically, there should be a provision in precision gear specifications which permits the acceptance of a high-quality gear, low TCE, even though its size is out of tolerance, provided

*American Standard, Inspection of Fine Pitch Gears, AGMA 236.04, ASA B6.11-1956.

the gear is used in an adjustable mesh situation.

When the gear is mounted on adjustable centers, the fact that the gear is slightly over or under size would not make any functional difference as long as it runs true. Adoption of this principle would lead to less scrap, contribute to better gear train motion, and save money. This concept can be more clearly visualized through inspection of Example 4.

Tolerance on Fixed Gear Centers: Many times the fixed centers of a gear train are jig-bored for accuracy in the gear box housing. However, workable tolerances are usually in the neighborhood of zero to +0.0002 in.

The typical co-ordinate dimensioning of two gear centers is shown in Fig. 4. The theoretical mounting distance, and the corresponding horizontal and vertical jig-boring co-ordinates are shown in Fig. 4*a*, while Fig. 4*b* shows the allowance made for the maximum tolerance on each co-ordinate dimension, and the effect on the actual center distance.

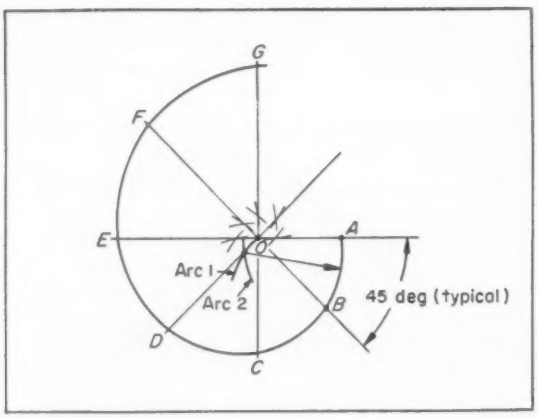
Lost motion due to this increase in center distance can be evaluated by Equation 2, and this increase is added to the design backlash. The new total backlash is then fed into the previous formulas or charts to compute the lost motion at the pinion.

The second part of this article will cover the effects that torsional shaft deflection, gear teeth deflection, temperature changes, and bearing loads have on lost motion in precision gear trains.

Tips and Techniques

Developing Scroll

Scroll developments are an essential portion in the design of radial blowers and centrifugal pumps. Layouts of this nature can be accomplished, when offsets and angles are specified, without the use of a French curve by the following construction.



1. With *BO* as a radius, turn arc 1 about center *B*.
2. With *BO* as a radius, turn arc 2 about center *A*.
3. Draw arc *AB* with center at the intersection of arcs 1 and 2.
4. Continue similar constructions from point *C* to point *G*.

It can be seen that this construction eliminates the inconvenience of French curve blending.—J. D. CHAPMAN, *Robbins and Meyers Inc., Memphis, Tenn.*

Integrals and Differentials

Frequently, oscillographic or other experimental curves must be graphically integrated or differentiated. For example, the distance a body travels may have to be computed from the velocity vs. time record, or the velocity of some mechanism may have to be found from a recording of its time-displacement curve.

The following gives a simple and concise description of the steps involved.

Step 1: If the curve is nonlinear in either the x or y axis, or both, it should be replotted to a linear scale using the proper calibration curves.

Step 2: To integrate, the area under the curve is carefully measured, usually in square inches, with a planimeter or some other device.

To differentiate, the angle or slope of the tangent at a chosen point is carefully measured with a protractor. The tangent value of this angle is obtained from function tables.

Step 3: Scale factors, by which the area or tangent must be multiplied to obtain the true integral or differential, are determined.

The x axis scale factor, K_x, is defined as the number of x units per inch along the x axis. As an example, a linear oscillograph record has an x axis time unit of 0.011 sec equal to 2.36 in. Therefore, $K_x = 0.011/2.36 = 0.00466$ sec/in.

Similarly, the y axis scale factor, K_y, is defined as the number of y units per inch along the y axis. Since the same oscillograph record has a y axis displacement unit of 2.37 in. represented by 2.62 in., the y axis scale factor is $K_y = 2.37/2.62 = 0.905$ in./in.

From the preceding analysis, the true integral = $(K_y)(K_x)$(area under curve), and the true differential = (K_y/K_x)(tangent of the angle). In determining these values, all of the units involved must be consistent.—A. E. NEWTON, *Beverly, Mass.*

Pen Storage

To prevent ink from drying in LeRoy pens, insert tips in a moist sponge and store in a closed jar. Pens may be stored in this manner for several days and be free of clogging when needed.—C. M. BERGER JR., *design engineer, Aerojet-General Corp., Frederick, Md.*

How to design for

LOW-PRESSURE MOLDING

. . . an economical process for producing complex reinforced-plastic parts

By JAMES C. ROLLER
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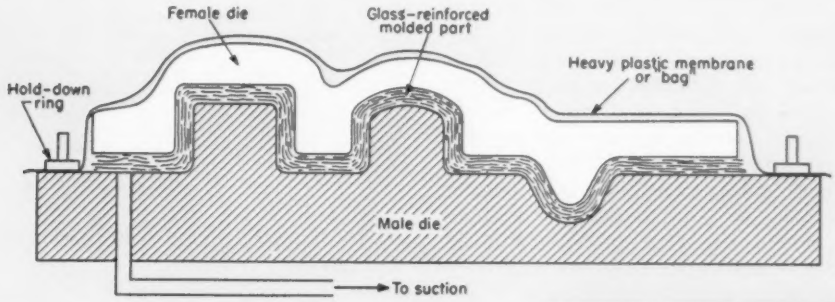
Ashtabula, Ohio

Process advantages
Tooling costs
Design considerations
Machining reinforced plastics
Finishing

BAG molding is an economical forming process which may be used to shape glass-fiber-reinforced polyesters under low pressure or vacuum. It has the advantage of utilizing simple dies of almost any rigid material, Fig. 1, and is especially suitable for prototype work and for relatively short production runs of large, complex shapes which would otherwise require expensive dies. Large production runs, however, can be accomplished more economically with matched metal dies and high-pressure presses. Generally, when runs exceed 1200 to 1500 units, cost of bag molding approaches that of high-pressure forming.

Properties of Glass-Reinforced Polyesters: Strength-to-weight ratio of a glass-reinforced polyester ranges



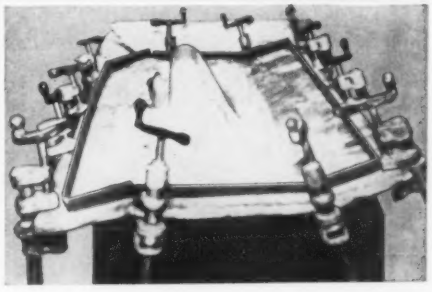


Fig. 1—Above—Bag molding with matched dies. Because of the low molding pressure, dies are made of glass-reinforced plastic. Matched dies insure uniform wall-thickness of the piece. Right—Alternate method of bag molding. "Bag" or plastic film is placed over a single die which contains the glass-resin lay-up. After the hold-down ring is clamped in place, bag is evacuated. Wall-thickness of the finished piece is not as uniform as that produced by matched dies. Single die may be male or female depending on which surface requires the final finish for appearance purposes

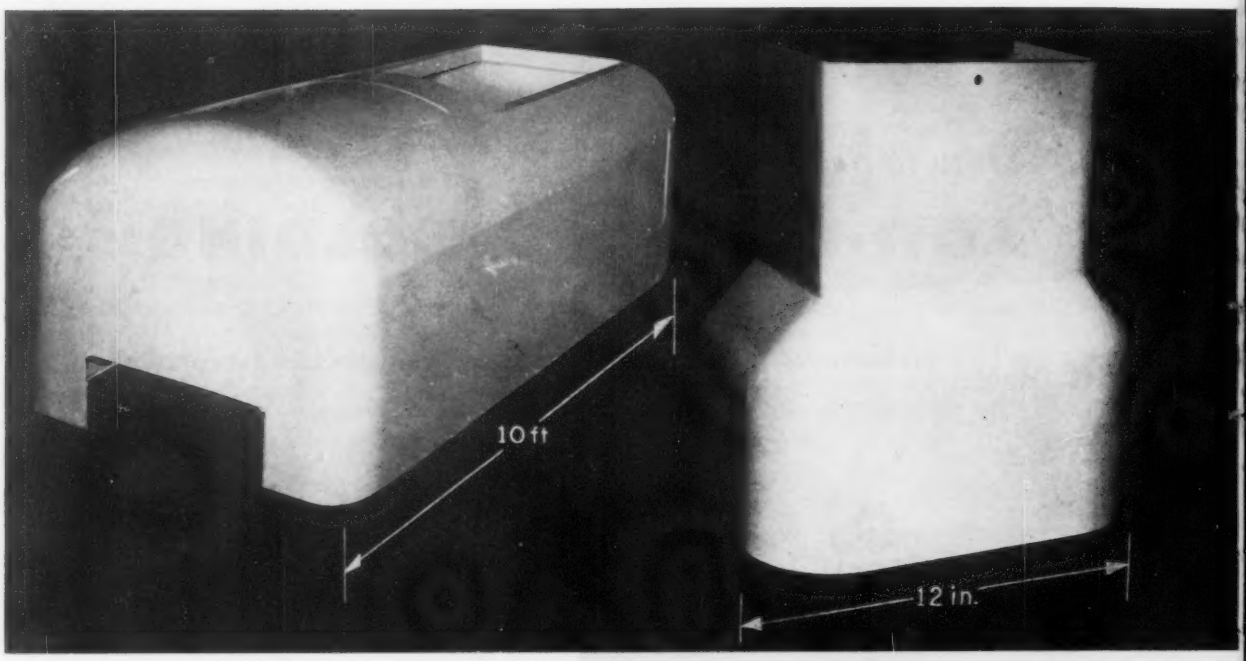


Fig. 2—Left Trainer unit, 10 by 3 by 3½ ft, molded from glass-reinforced plastic. Tooling costs for plastic die were less than $2000. Units cost less than $200 each in production lots of 50. Above—Shockproof, nonconducting machinery guard of glass-plastic. Guard measures 13 by 12 by 7 in. Tooling cost was approximately $200. Cost of each unit is less than $7.00 in production lots of 25

from 10,000 to 60,000 psi depending upon the combination of resin and glass fiber used. This high ratio makes it possible to design a thin-walled part of nearly half the weight of a similar steel part. However, when a loading condition is specified, wall thickness of the glass-reinforced part must be more than twice that of the steel.

Strength of a glass-reinforced polyester is also a function of temperature. Normal polyester weakens rapidly at temperatures above 180 F, but special resins are available for applications to 400 F. In general, performance of this material is satisfactory over a temperature range from −60 to +250 F. Contact with corrosive liquids reduces the high-temperature limit.

Electrical and thermal insulating properties of reinforced polyesters are excellent. Dielectric strength is 300 to 600 v per mil, and the thermal insulating value is approximately half that of cellular polyethylene but can be varied over an exceedingly wide range according to type of resin used and percentage of glass content.

Glass-reinforced polyesters will not rust, rot, or corrode galvanically and are particularly weather-stable. They possess generally excellent resistance to organic solvents and good resistance to other corrosive agents with the exception of strong acids and alkalies, and some oxidizers. Other properties of bag-molded, reinforced polyesters are shown in Table 1.

Tooling Costs for Bag Molding: A low tooling cost is one of the outstanding characteristics of this process. Die costs range from $15.00 to $30.00 per sq ft for average-size parts depending on complexity of design features. Price per piece produced in matched dies varies from approximately $1.25 per sq ft for large, simple shapes to $2.00 per sq ft for smaller, complex shapes. Prices are based on quantities of 50 to 100 pieces with wall thicknesses from 0.10 to 0.125 in.

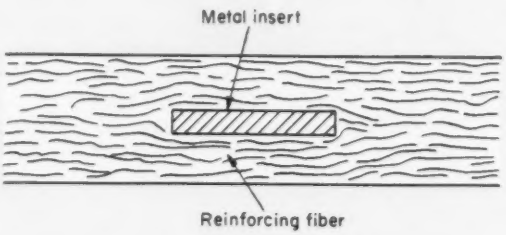


Fig. 3—Metal insert embedded in glass-reinforced plastic. Satisfactory performance of inserts is obtained only when insert is completely surrounded by the reinforcing medium. Inserts must be designed so that they will not interfere with die closure

As an example of relative tooling costs of reinforced-plastic parts and comparable metal parts, the following figures pertain to the Chevrolet Corvette sports car body: $500,000 to produce the required 41 body parts in reinforced plastic and an estimated $4.5 million to produce the same quantity of parts in steel. Fig. 2 shows range of sizes and tooling costs for other glass-reinforced plastic parts.

Only 4 to 5 days are required to produce the first item on production dies from the time the model is available. This is based on an average-size shape of 3 by 3 ft and of moderate complexity.

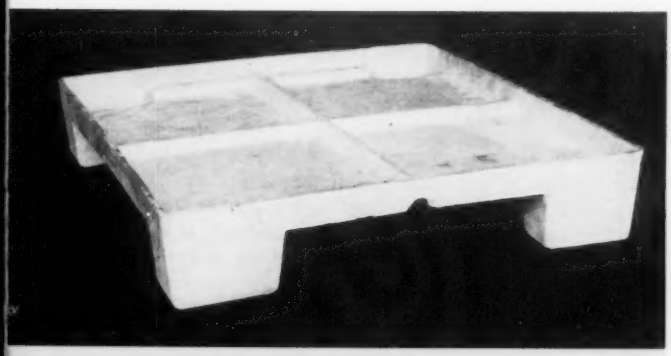


Fig. 4—Strengthener ribs designed as an integral part of the structure. Note that ribs and feet are hollow which conforms to good design practice

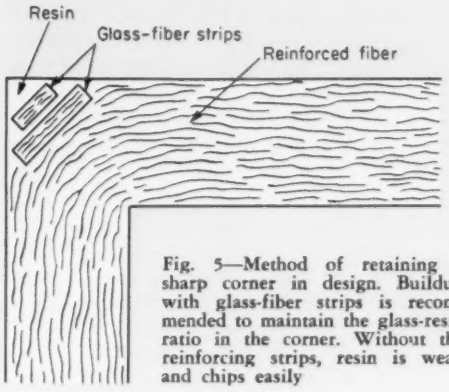


Fig. 5—Method of retaining a sharp corner in design. Buildup with glass-fiber strips is recommended to maintain the glass-resin ratio in the corner. Without the reinforcing strips, resin is weak and chips easily

Speed with which dies are made can be attributed to the fact that any existing model or product can be used in lieu of a regular patternmaker's model. Also, models of practically any material are suitable for die making.

Sensitivity of the die to model details will vary with material used. Plastic dies, for example, pick up exact surface details and, for this reason, the die model is usually finished to the customer's specifications. Curves, angles, and other complex shapes are easily reproduced in glass-reinforced plastic dies because of the ease with which the resin flows. Dies are dimensionally stable when the resin has set, and complex shapes are no problem.

Design Considerations: Criteria which govern the complexity of shapes produced by bag molding include wall thickness, undercuts, draft angle, and corner radii. Wall thickness should be uniform throughout the entire shape. It must be emphasized that lugs and bosses, common in metal-casting design, cannot be molded in glass-reinforced plastic. If required, they must be attached as separate pieces of plastic or metal to the main molded piece. For example, automobile hoods are composed of a glass-plastic outer surface panel and a flanged-channel section joined to the underside. Here, the plastic channel section contains metal tapping plates for attachment of hardware. Sandwich construction can also be used where thin, outer skins of glass-reinforced plastic are strengthened by an inner honeycomb material or foam-in-place polyurethane.

Metal parts are usually riveted or bolted to reinforced-plastic shapes. They are seldom joined with adhesive. Another method of joining metal parts to reinforced plastic is to embed the part directly in the plastic material. In designing for an embedded metal part, it must be remembered that the part has be be accommodated in the mold and that it must be completely enclosed within the glass reinforcing medium, Fig. 3. Strengthening ribs can be molded into a piece and may be designed as an integral part of the structure, Fig. 4.

Undercuts can be accommodated only on split molds. Where these are essential in design of the piece, it is sometimes better to produce the part in two sections and then join them. Use of split-molds, however, is usually unsatisfactory because flash forms where the molds join, and no vacuum can be used. Also, matching dies cannot be used, and nonuniform wall thickness results. To maintain good wall structure and surface, a 2-degree minimum vertical draft angle is necessary.

For a proper glass-resin ratio in corners, a minimum radius of $\frac{1}{8}$ in. is recommended. Where necessary, a sharp corner can be produced by reinforcing it with glass strips, Fig. 5.

Available Colors: The resin itself can be colored at no extra cost when the piece is formed. The natural finish of glass-reinforced plastic is "flat," has a slight texture, and sometimes shows minor porosity. The glass-plastic is also subject to abrasion, a factor to consider when specifying a natural finish.

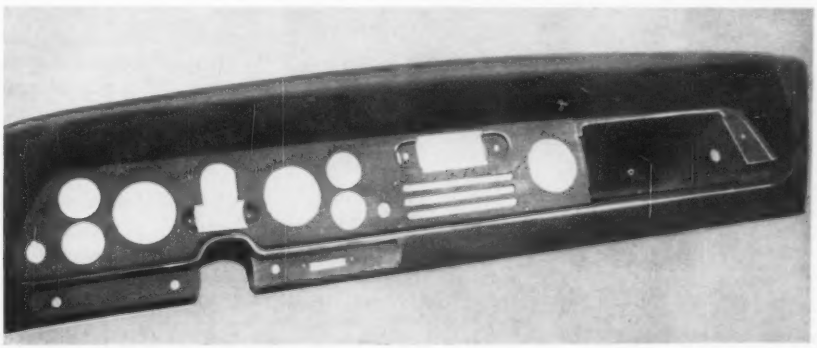


Fig. 6—Bag-molded panel ready for lacquer finish. After curing and trimming, panel was prime coated

Degree to which the glass fibers are accentuated on the surface can be controlled from virtually invisible to highly raised. For unusual effects, fibers can be furnished in contrasting colors to the resin.

Surface Finishes: Three surface finishes can be supplied: The natural flat finish described above, a colored, "gel-coated" glossy finish which is uniform in color and very smooth to the touch, or a high-quality lacquered finish such as found on automobile panels. Fig. 6 shows a finished piece prime coated for lacquer treatment.

One obvious advantage of glass-reinforced plastic is that rust cannot form beneath the finish coating. Ability of this material to maintain its original appearance and strength over long periods of time is one of its outstanding economic advantages. Another unusual characteristic of reinforced plastic is the fact that it will not dent because its yield strength and ultimate strength are identical.

Machining: Glass-reinforced plastics can be sawed, sanded, drilled, punched, and routed. Carbide tools are generally used, and dust generation is a problem when the material is machined dry. For drilling, an inexpensive glass-plastic jig is usually made with a configuration identical to the part and in which hardened-steel bushings are embedded.

In trimming flash, straight lines are cut with a carbide saw, Fig. 7. Contours are formed with a plastic router fixture and a high-speed carbide-tipped router bit or with a high-speed abrasive wheel, depending upon area covered.

Bonding: Glass-reinforced plastic parts are joined with the usual mechanical fasteners, or they can be joined with filled polyester using a room-temperature catalyst. The heavy paste mixture is applied to both surfaces to be joined, and the assembly is clamped and allowed to cure at room temperature. Tests show that this adhesive bond provides an 800-psi tensile-shear strength.

Tolerances: Part dimensions and shape are, of course, dependent upon the details of the original die model. Final wall thickness, however, is independent of the model and is determined at the time of die making. With matched dies, wall thickness can be held to ± 0.010 in. where draw is shallow The deeper the draw, the greater the variation in wall thickness. Where close tolerances on wall thickness are required, the bag-molding process is not suitable. Matched steel dies under pressure, however, can attain the required tolerances. An important consideration in tolerances is the fact that edges cannot be molded to final shape but must be cut when removing the flash. Where close edge tolerances are required, machining time becomes a major cost factor.

Table 1—Properties of Reinforced Plastic Parts*

Tensile strength, psi	11,000 to 15,000
Flexural strength, psi	20,000 to 26,000
Flexural modulus	1.5×10^6
Glass content, per cent	30 to 35

*Parts are commercial grade. Higher strengths are possible in special applications.

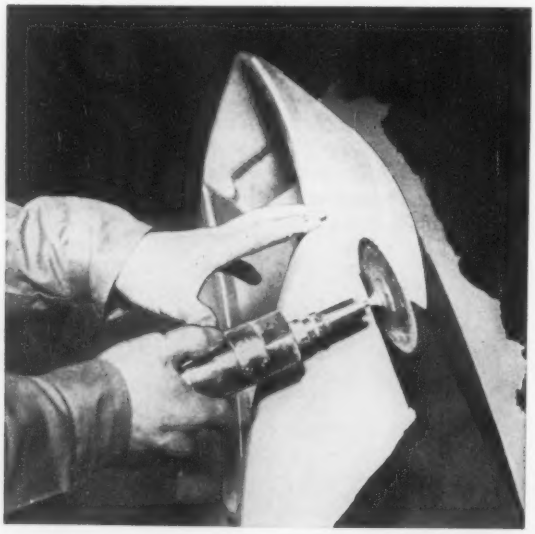


Fig. 7—Rough trimming of flash with carbide saw. High-speed router is used for fine trimming, and contours are formed with a carbide-tipped router bit

Tips and Techniques

Critical Speed of Rolls

Design to avoid the critical speed can prevent vibrations in rotating rolls. Assume the design of a particular roll and calculate its first critical speed. To determine whether redesign is necessary, compare the first critical speed with the expected operating speed. In most applications the second critical speed is never reached.

The first critical speed, N_c in rpm, can be obtained from

$$N_c = \frac{187.7}{\sqrt{Y}}$$

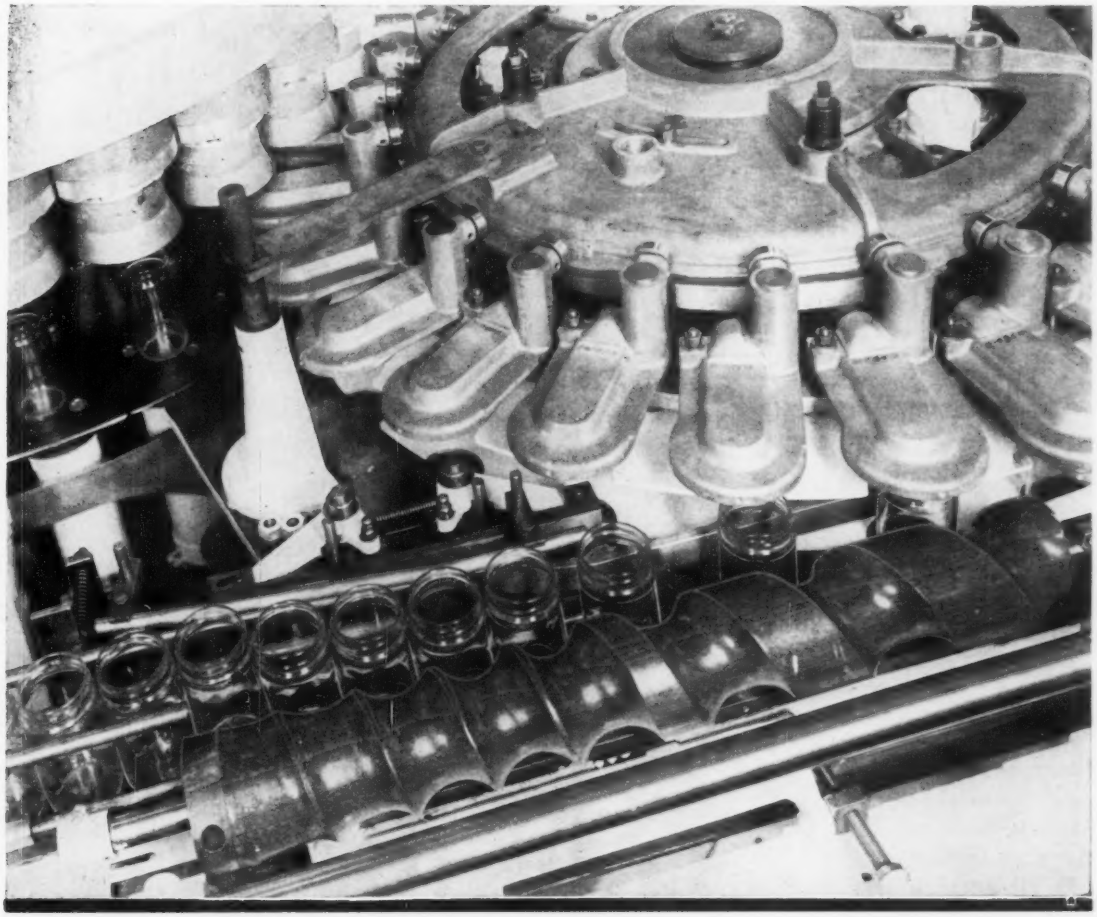
where Y = maximum static deflection, in. The value of Y can be determined from

$$Y = \frac{5WL^3}{384EI}$$

where I = moment of inertia of the roll body section, in.^{4}; W = weight, lb; L = length, in.; and E = modulus of elasticity, psi.

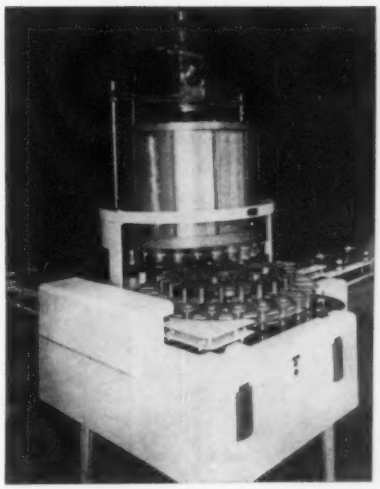
Multiply rpm by $\pi D/12$ to obtain sfpm, where D = roll diameter, in.—INDUSTRIAL ROLL REPORT 13, *Rodney Hunt Machine Co., Orange, Mass.*

Plastic Helix Spaces Jars



VARIABLE-PITCH HELIX properly spaces out glass jars entering an instant-coffee packing machine. The helical member is machined from NEMA Grade C Bakelite. The contours are filed to blend, and the unit is varnished. The nonmetallic spacing and feeding member is mounted on bronze bushings.

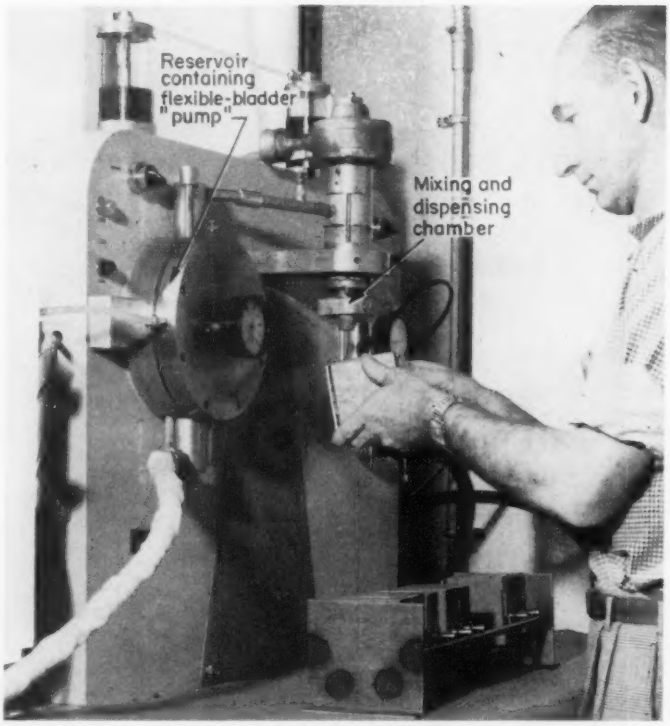
Pneumatic Scale Corp. Inc., manufacturer of the machine, reports that the Bakelite reduces noise and increases wear life in comparison to metal helices.



Proportioning Bars Control

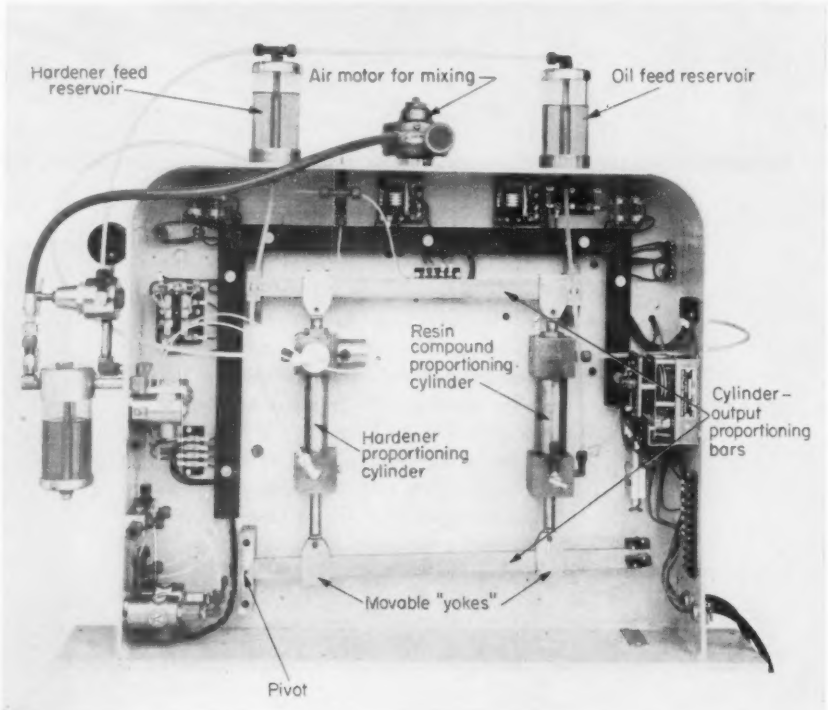
ACCURATE MIXING of liquid resins and hardeners is easily accomplished by a novel system of volume control and pumping. The system is applied in a machine designed to embed and pot metal parts in plastic, such as electrical connectors. As reported C. A. Harper and C. D. Larson, Westinghouse Electric Corp. and August Kraft, Automatic Process Control Co., the principle of volume-displacement eliminates problems of pumping variable-viscosity materials.

Air pressure forces hardener and resin compound from separate storage tanks and through fed lines to the catalyzing and dispensing chamber. Proper flow direction is controlled by a series of air-operated check valves.

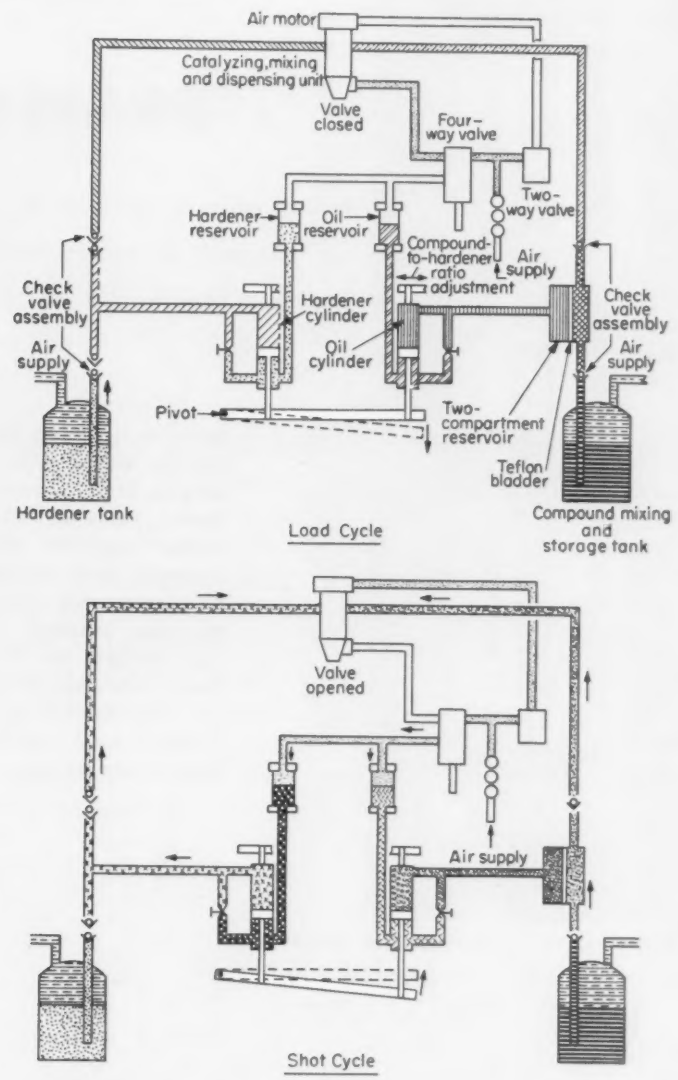


RESIN-TO-HARDENER RATIOS are determined by the relative positions of two cylinders on a pair of proportioning bars. Changing the location of the proportioning cylinders on the bars changes their volume displacement and, hence, the ratio of resin to hardener which is mixed together during the shot cycle.

In operation, the machine forces hardener into one of the cylinders during the **load** stroke. Hardener is forced from this cylinder section into the mixing and dispensing chamber on the **shot** stroke. Resin is loaded into the machine and dispensed at the same time as the hardener.



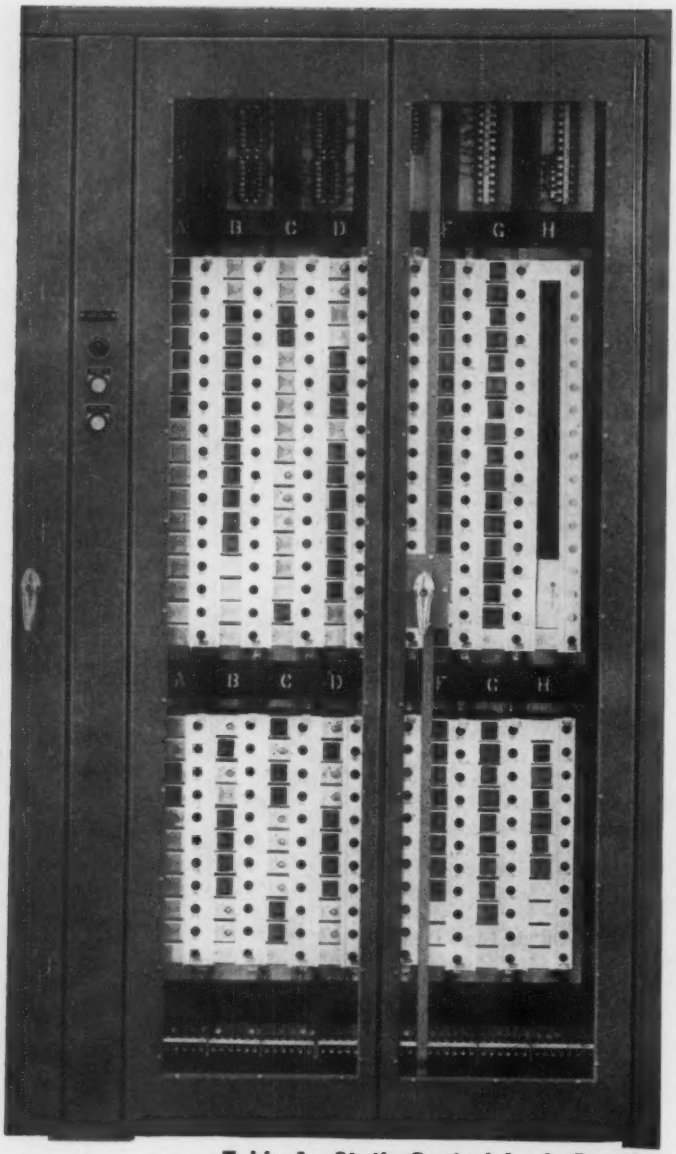
Output Ratio of Cylinders



FLEXIBLE-BLADDER "PUMP" in this machine eliminates the problem of wear in pumping liquid resins containing abrasive fillers. The Teflon bladder divides the cylindrical reservoir into two compartments where pumping action takes place. Heated and pressurized resin compound is forced into one side of the reservoir and low-viscosity oil is held on the other side. The oil line is connected to the second proportioning cylinder. During the shot cycle, a given volume of oil is displaced from the second cylinder which forces the bladder outward. This action pumps resin compound into the mixing and dispensing chamber.

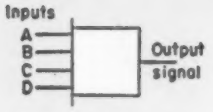
By E. L. RUDISILL
Application Engineer
General Purpose Control Dept.
General Electric Co.
Bloomington, Ill.

STATIC



Static control panel containing eight rows of plug-in logic elements. Round holes in cover plates between logic elements show monitor lights which are clipped to side brackets on logic-element housings. These lights show output condition of each element and simplify malfunction location.

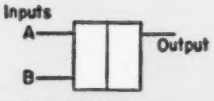
Table 1—Static-Control Logic-Function Symbols



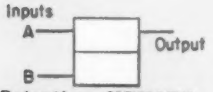
AND Function: All inputs to an AND function must be present to establish and maintain the output.

OR Function: Any input or any combination of inputs must be present to establish and maintain an output.

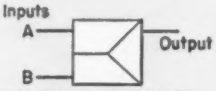
NOT Function: An input will NOT produce an output. Conversely, no input will produce an output.



Basic MEMORY Function: A momentary input to the *on* section will produce a maintained output. A momentary input to the *off* section will cause the output, if present, to stop.



Retentive MEMORY Function: The retentive MEMORY is a basic MEMORY with the added capability of always remembering its output state when system power is interrupted and later restored.



Off-Return MEMORY Function: The *off*-return MEMORY is a basic MEMORY with the added capability of always returning to the *off* condition when system power is interrupted and later restored.

Time DELAY Function: A maintained input will produce an output after an intentional time delay.

Amplifier: Used to convert an output signal from a logic element to a large power output required to actuate the controlled device.

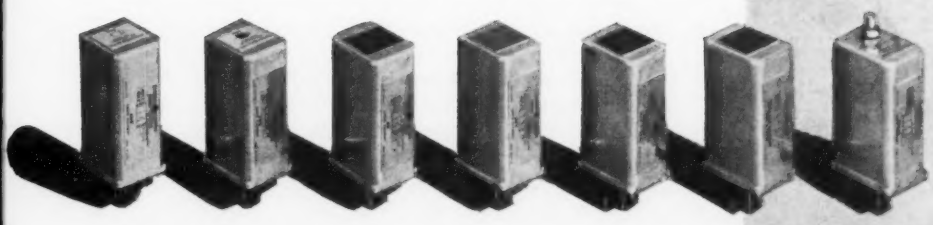


Fig. 1 — Plug-in logic elements for static control systems. From left to right, the units are a two-input AND, four-input AND, three-input OR, two-input NOT, retentive MEMORY, off-return MEMORY, and adjustable time DELAY. Logic function symbols on color-coded nameplates on top clearly identify elements. Nameplates on side identify the eight terminal-board connections in logic-element receptacles

CONTROL

. . . of machine operation by small magnetic-amplifier "switches" performing AND, OR, NOT, MEMORY, and DELAY functions

What is static control? Where is static control used? How does static control work? These are questions commonly asked about this relative newcomer in electrical control. Much of the confusion in understanding static control has come about by comparing it with relay control. They are two basically different control approaches and should be treated as such. This article shows how to design a control system for a machine with static type "switching" elements, and describes exactly how each element works and is controlled.

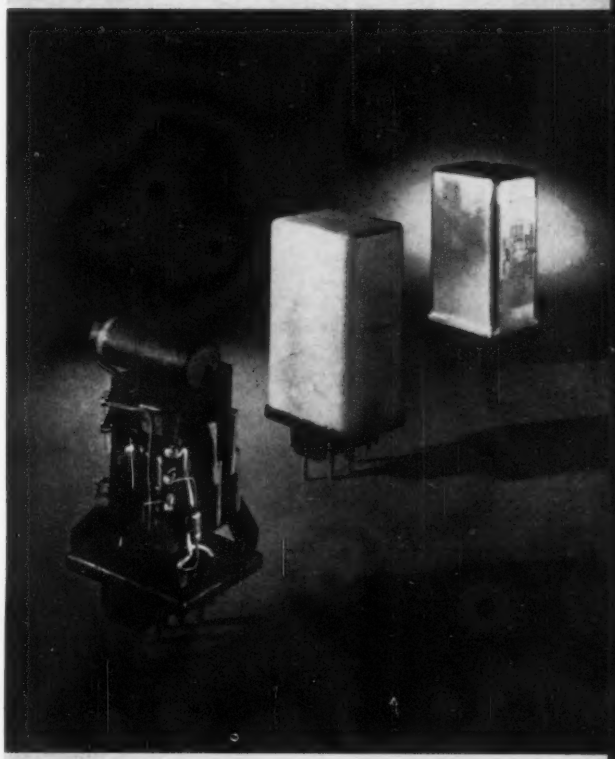


Fig. 2—Four-input AND logic element before and after encapsulation in a soft sponge-like compound. Magnetic-amplifier circuit assembly at left is placed in aluminum can at right. Resilient potting material, poured into the bottom of can prior to inserting assembly, is made to foam up through circuit components by a catalyst

MACHINE control can be broken down into three parts — information, decision, and action. Specifically, the information section of a machine is comprised of its sensing devices, such as limit switches, pushbuttons, pressure and temperature switches, and any other devices that can receive and transmit information which is pertinent to the control.

This information must be assimilated and correlated to arrive at a decision to do something. This is the decision portion, or "brains," of the control.

Once a decision is reached, action must be taken in terms of operating a solenoid valve, a contactor or starter, an indicating light, or some other device that will perform the desired result.

Static control, as discussed in this article, performs the decision-making portion of the over-all control. It is a method of electrically controlling machine functions with magnetic amplifiers and other static devices which are not subject to wear or erosion. This means operating life of the control is greatly extended and reliability is increased tremendously.

Magnetic amplifiers and other devices used in static controls operate in a different manner than relays, which have long been used in electrical control circuits. The main difference is that these static devices can accept one or more inputs and

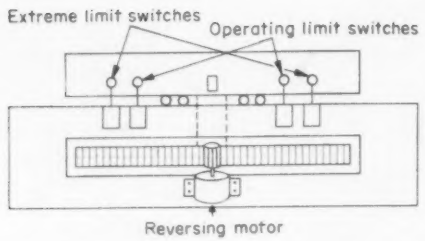


Fig. 3—Location of switches and motor on planer table for hypothetical static-control design problem

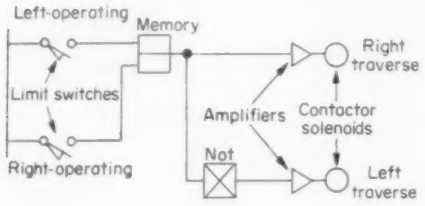


Fig. 4—Logic functions and other electrical controls required for continuously oscillating planer table

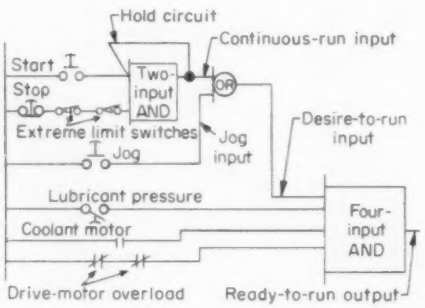


Fig. 5—Logic functions and other controls for starting, stopping, and jogging planer. Circuits controlling lubricant-pressure, coolant-motor, and drive-motor overload circuits must be closed before machine can operate

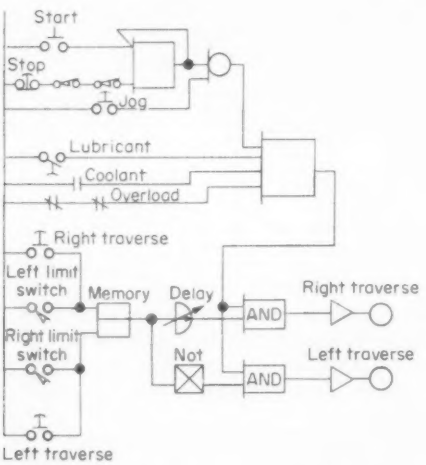


Fig. 6—Logic circuit for oscillating table is combined with the manual and protective circuits. Additional functions and switches are added to make sure table starts in the direction desired

produce a single output. Relays, on the other hand, accept a single input (to the coil) and provide one or more outputs, depending on the number of contacts used. Therefore, a different approach is taken in designing static controls—use of logic functions. In short, all intelligence is broken down into five basic functions—AND, OR, NOT, MEMORY, and DELAY, Table 1. Each function can handle one or more inputs and convert these to a single output.

To keep the size, weight, and expense of magnetic-amplifier type logic functions, Fig. 1 and 2, to a reasonable value, they are constructed to handle only small amounts of power; their output is considerably less than 1 watt. Therefore, when a signal output shows that a decision has been made to take action, it is necessary to amplify this signal into usable power to actuate the controlled device. The logic symbol for the amplifier is also shown in Table 1.

Static-Control Design Example

Assume that design specifications call for a static electrical control system on a planer table which is shown by the sketch in Fig. 3. Assume further that a reversing motor must drive the table back and forth. For example, if the right-traverse contactor is actuated, the table should be driven to the right. When the right-operating limit switch is actuated, the right-traverse contactor is de-energized and the left-traverse contactor is operated so that the table is driven to the left until it hits the left operating limit switch. Certain protective controls as well as direction from the machine operator must be incorporated in the circuit. The protective controls wanted are motor overload protection, interlocking with the coolant supply, and minimum lubricant pressure.

Step 1: First the continuous reciprocating motion can be set up with logic functions, Fig. 4. In this case, there are left and right-traverse contactor solenoids to operate. Logically speaking, when the right-traverse amplifier is actuated, the left-traverse amplifier must not be operated. Therefore, the input to the right-traverse amplifier must also be fed to a NOT element driving the left-traverse amplifier to keep the latter from operating.

When the table actuates the left-operating limit switch, the right-traverse amplifier is to be actuated. However, when the right-traverse amplifier is actuated the table is driven away from the left-operating limit switch. Obviously, the limit-switch operation is momentary, and the table control must remember the direction to be traveled until the opposite limit switch is actuated. Thus a memory is required. A MEMORY control element, which is turned *on* with the momentary input from a limit switch, sends an electric signal to both the right-traverse solenoid amplifier and the NOT element. This action turns off the output of the NOT element; the left-traverse solenoid receives no power.

Step 2: The table progresses from the left side until

it actuates the right-operating limit switch. At this point the right-traverse amplifier must be turned off and the left-traverse amplifier energized. In this case, both requirements can be achieved by using the right-operating limit switch, which turns off the MEMORY output, stopping input to the right-traverse amplifier and to the NOT element. With no input to the NOT element, it produces an output which drives the left-traverse solenoid, and the table is actuated to the left to complete the cycle.

Step 3: Additional controls can now be added. Suppose two types of operation are required: 1. Continuous running. 2. Jogging. Design in a start button in series to one input of a two-input AND, Fig. 5. Since the stop button and the extreme limit switches are of the normally closed variety, they can be placed in series to the second input of the two-input AND. When the start button is pressed, an output will be present from the two-input AND.

However, the operator should not have to stand at the control panel with his finger on the start button at all times. To overcome this difficulty, a portion of the output is fed back into the same input used by the start button. Once an output has been established, the operator can release the start button and the output will be maintained, since the two-input AND is now sealed in. (This is similar to the way a relay holds itself closed with a holding circuit through one of its own normally open contacts.) Output from this AND function will, of course, signify direction by the operator for continuous running.

Step 4: It is now desired either to run continuously or jog. To accomplish this, an OR element with one input from the output of the two-input AND and the other input from a jog button is used. The output of the OR shows that the operator wants to run the machine.

Step 5: Next, assume protective functions are needed. Suppose the desire of the operator to run the machine is combined with a minimum lubrication-pressure requirement. Also, assume the coolant motor must be operating and the drive-motor, overload-relay contacts must be closed. These circuits are connected to a four-input AND, the output of which signifies "ready to run."

Step 6: The table-reversing portion (Fig. 4) is combined with the manual and protective functions (Fig. 5), as shown in Fig. 6.

Step 7: The circuit is virtually complete except for two things. For jogging operations and start-up, it may be desired to make sure the table starts in a definite direction. The direction can be easily selected by presetting the MEMORY *on* or *off* by push-buttons in parallel with the left and right limit switches. Also, if the table must stop at one end of its travel for chip removal, a DELAY function could be added to the automatic-cycle portion, completing the desired operating cycle requirements.

How Logic Functions Work

Although each manufacturer of magnetic-amplifier type static logic functions employs slightly different circuit assemblies, they are similar in design and operation. Only one system is described here.

Input-Output Characteristics: For the moment, do not consider what happens inside a magnetic-amplifier logic element, but merely what happens to the output when an input is applied. Since logic elements discussed here are essentially dc devices, input signals can be either negative or positive, although the output is always positive. If a strong negative signal were applied to a magnetic-amplifier logic element and were gradually changed from a minus input through zero to a plus input, the output would look something like that shown in Fig. 7*a*. With no alteration, this is a NOT function; with no input, the output is in the *on* zone, and with a negative input, the output drops into the *off* zone.

To obtain an OR function, a negative signal (bias) is built into the logic element. The bias will hold the output in the *off* zone with no external signal applied, Fig. 7*b*. Any external signal applied

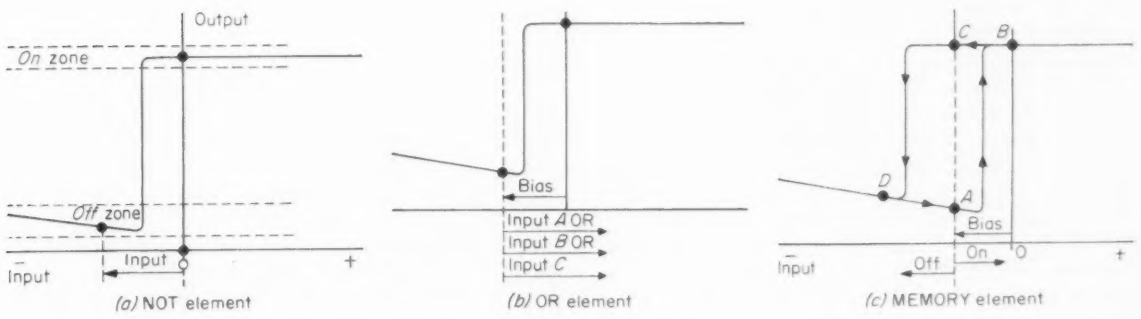


Fig. 7—Input-output characteristic curves of NOT, OR, and MEMORY elements

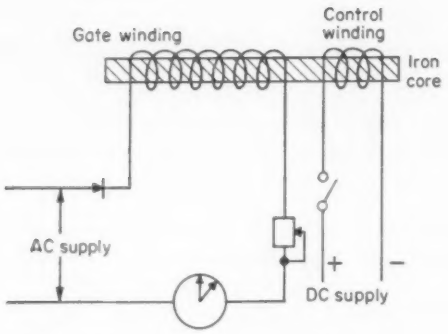


Fig. 8 — Basic magnetic-amplifier design for *on-off* "switching"

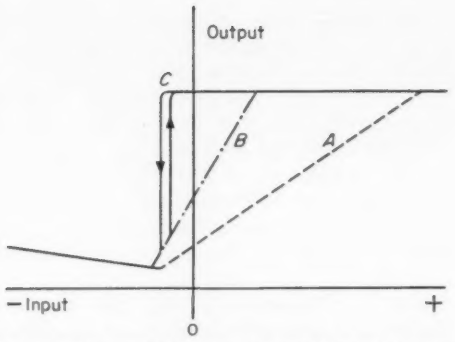


Fig. 10—Characteristic curves of amplifiers with cores made of transformer iron, *A*, square-loop material, *B*, and square-loop material plus feedback, *C*

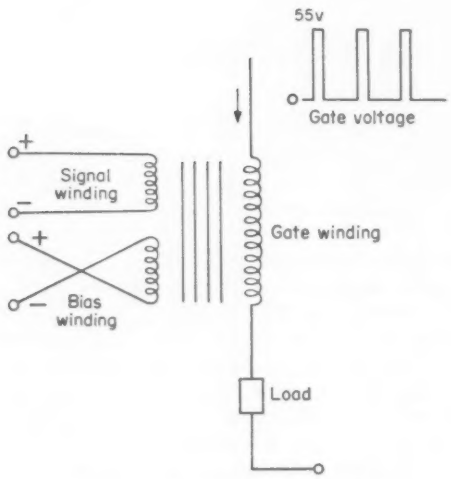


Fig. 9 — Basic magnetic-amplifier circuit with bias winding added

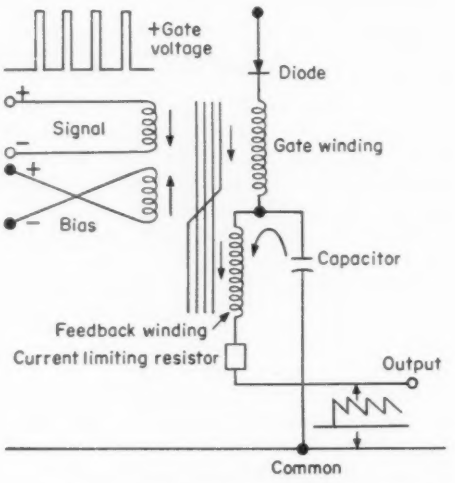


Fig. 11—Basic static-control element circuit with capacitor and feedback winding to produce a digital output

in the positive direction will cause the output to go from *off* to *on*. Since these are magnetic-amplifier devices, multiple inputs are possible. Consequently, with more windings, this OR element can be turned on with input *A* or input *B* or input *C* or any combination of *A*, *B*, and *C*, as shown in Fig 7*b*.

The characteristic output curve of the MEMORY element is shown in Fig. 7*c* and follows the path *DABCD*. Obviously, the element remains in the *on* condition even though the input is very negative. However, with a strong enough negative signal, the input finally does drop down to the *off* condition at *D* and begins to retrace the original curve.

If the MEMORY element is biased and no external signal is applied, the output is at point *A*. If a positive *on* signal is applied, the output is driven from *A* to *B*. If the *on* signal is removed, the output cannot come directly back to *A*, since this is strictly a one-way path. Instead, the output goes from *B* to *C*, where it is held by the bias voltage. Under this condition, the element produces full output with no externally applied signal and, therefore, has remembered a momentary input. To turn the element *off*, it is necessary only to apply a negative *off* signal. The output then goes from *C* to *D*. Removal of the *off* signal causes the output to go from *D* back to the original *A* position.

The AND element and the DELAY element operating principles can be better seen by studying some basic circuits.

Basic Logic Circuits: In a basic magnetic amplifier, Fig. 8, the amount of current through the main or "gate" winding is controlled by the state of saturation of the iron core within the gate winding. If the iron core is sometimes made to look like air to the gate winding (magnetically speaking), appreciable current will flow because the "gate is opened." If the iron core really looks like iron, the "gate is closed" and little current flows. This is, in effect, a static contactless "switch." *Off-on* control is achieved by adding a direct-current control

winding which, when energized, turns the "switch" *on* by driving the iron to saturation and effectively making the iron bar act as if it were out of the circuit.

In Fig. 9 is a basic magnetic-amplifier circuit with a negative bias winding added. To understand the operation of this circuit, make three assumptions: 1. There is no signal present on the signal winding. 2. The bias winding is always energized with dc current. 3. Initially the iron is not positively saturated. If under these conditions the gate voltage, in the form of narrow, regular-interval dc pulses, is applied at the top of the gate winding, the first pulse of current goes down through the gate winding. Since the core is not in positive saturation, a large back emf is induced in the gate winding which limits the current through both the gate winding and load to a small magnetizing current. The first pulse does accomplish one thing, however; it succeeds in driving the iron core almost to positive saturation.

The effect of the bias voltage makes itself felt between the end of the first pulse and the beginning of the next pulse. The bias drives the core toward negative saturation essentially undoing the work of the first pulse. Consequently, with no dc signal applied, the pulses of gate voltage try to drive the core into positive saturation. Between pulses, the bias "resets" the core and no appreciable current flows through the load.

If a dc signal is applied, however, the gate pulse immediately following will drive the core toward positive saturation as before. However, the signal voltage nullifies or neutralizes the effect of the bias signal such that the bias cannot reset the core. Therefore, when the next gate pulse comes along, the core is nearly saturated. Under this condition, the impedance of the gate drops approximately 90 per cent, a relatively high current flows in the load, and there is an output. As soon as the signal is removed, the bias rests the core and the signal output stops.

AND, OR, NOT, MEMORY Circuits: To make a magnetic-amplifier logic function operate correctly, a special square-loop core material is used which is made of a specially processed nickel-iron alloy. If transformer iron were employed, the output would appear as shown in curve *A*, Fig. 10. Square-loop core material improves the output curve considerably, although there is still a certain analog portion, as shown in curve *B*, Fig. 10.

To produce the required digital *on* and *off* characteristic for static control functions, as depicted by curve *C*, Fig. 10, a feedback winding and a capacitor must be added, Fig. 11. Assume an input signal is applied to this circuit. The first gate pulse comes down from the gate winding and drives the core almost to saturation. Since the bias is neutralized by the effect of the dc signal present, the core remains very close to saturation. The second pulse now comes through the gate and a small current immediately begins to flow down through

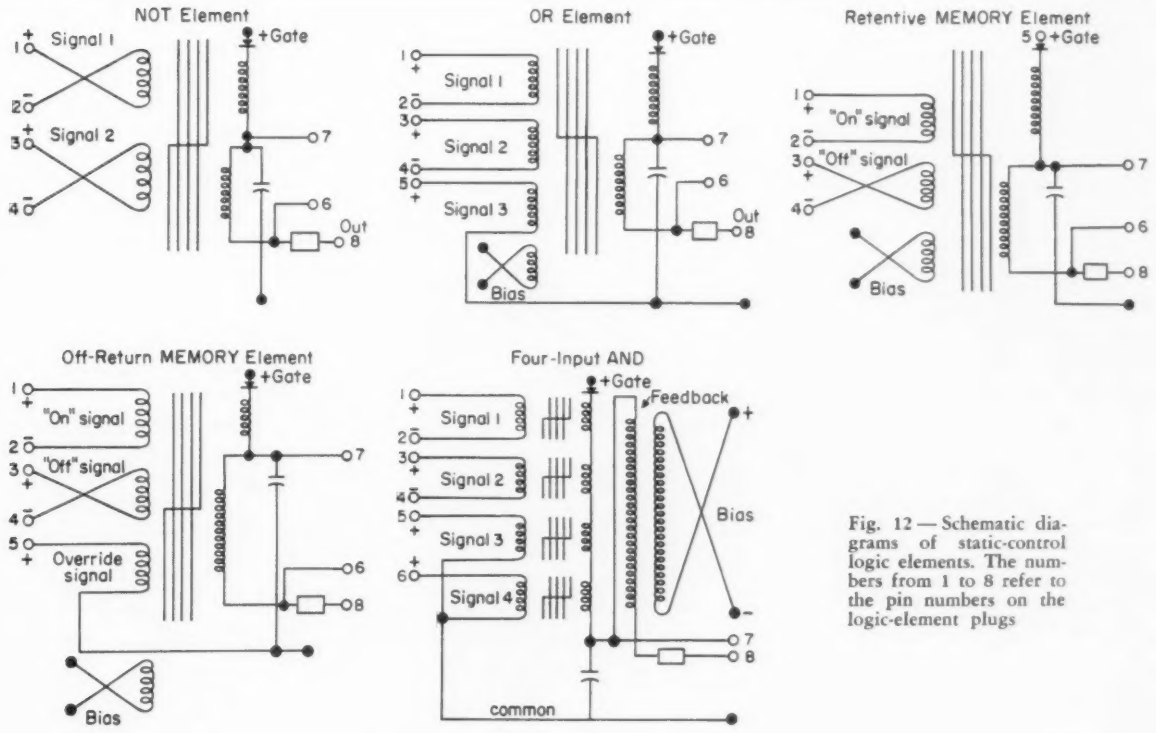


Fig. 12 — Schematic diagrams of static-control logic elements. The numbers from 1 to 8 refer to the pin numbers on the logic-element plugs

the gate winding, feedback winding, and load with the core already about 80 per cent positively saturated. A small current flowing through the feedback winding, which is wound around the same iron core, adds to the core saturation and immediately drives the core to complete saturation. As a result the output load current jumps from a very low value to full output almost instantaneously.

At the same time the output current begins to flow, the capacitor is also charged by the second pulse. At the end of the second pulse, the capacitor discharges in the path shown by the arrow through the feedback winding and the current-limiting resistor to the output. The capacitor is prevented from discharging back through the gate winding by a diode above the gate winding. The capacitor discharging between pulses produces a sawtooth output voltage which is essentially dc with a ripple. This output current, even with a ripple, is good enough to use as a driving signal for succeeding elements. By discharging back through the feedback winding, an additional signal is developed which tends to hold the core in positive saturation. Thus, the digital *on* and *off* action is achieved.

If the number of feedback turns were increased by a large number, the turn-on would be just as it was before, but the effect of the capacitor discharging through a large feedback winding requires an extremely strong signal to turn off. The resulting effect is the characteristic MEMORY function curve, Fig. 7c.

With these fundamentals in mind, it can be seen how the NOT, OR, MEMORY, and AND elements operate, Fig. 12. The primary difference between the *retentive* and the *off-return* MEMORIES is that gate power is established before bias power in the *retentive* MEMORY, whereas bias power is established before gate power in the *off-return* MEMORY element.

To obtain a dependable AND function, the gate and bias windings are wound around a number of cores, and each core has its individual signal winding. To achieve an output through the load, all four cores must be driven to saturation, which means that all four signals must be present. This arrangement makes it possible to operate with utmost reliability even if over-tolerance signals are present, because once a core has been driven to saturation, additional current in the signal wiring will have no effect.

DELAY Circuit: As shown in Fig. 13, the basic DELAY function device has two magnetic cores, two gate windings, and a mutual linking winding which is common to both cores. The gate pulses applied at regular intervals alternate between gate 1 and gate 2. Each pulse going through each gate winding will drive its respective core only a small percentage toward saturation, as contrasted to the gate windings of the other elements previously discussed in which one pulse would drive its core into almost complete saturation.

The mutual linking winding is so wound that when a voltage is induced in it as a result of a flux change in core 1, it causes a flux change in

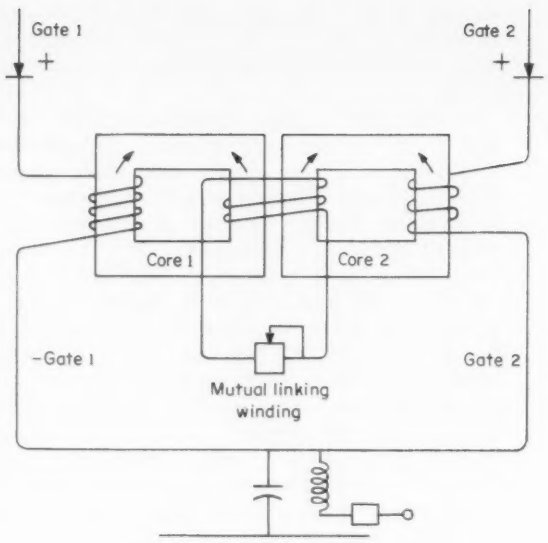


Fig. 13—Simplified sketch of a basic time-delay logic function

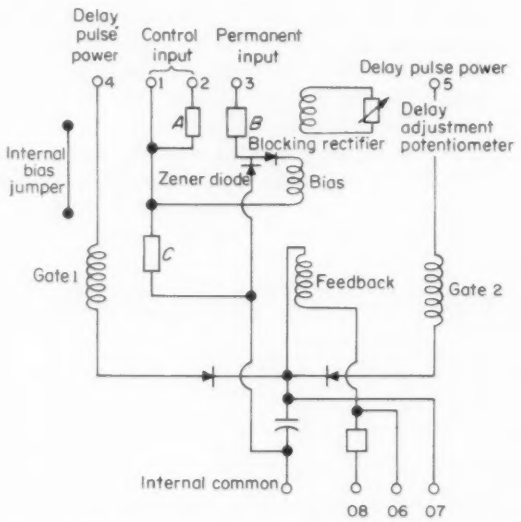


Fig. 14—Schematic diagram of a complete time-delay logic element with potentiometer time-adjustment control

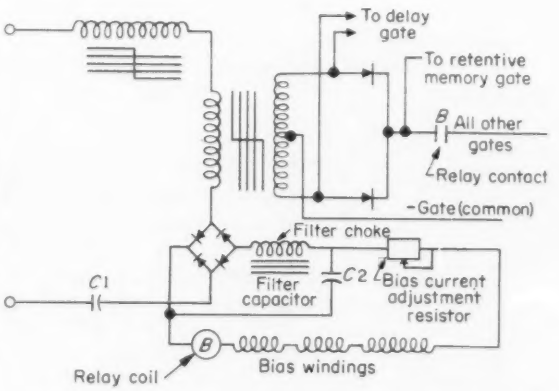


Fig. 15—Power supply for static-control logic elements

core 2 which drives it toward negative saturation. Likewise with positive pulses applied to core 2, the mutual winding produces a negative saturation effect in core 1.

If the mutual linking winding had no resistance and no losses, the two cores would buck each other indefinitely and neither would ever become saturated. However, if a loss is introduced in the mutual linking winding by inserting a potentiometer in the circuit, the amount of resetting action can be varied and eventually both cores will be saturated. As a result, a definite amount of time delay can be achieved.

The control and bias-winding arrangement on the DELAY element, Fig. 14, is quite different from the other static control elements discussed. The reason for this difference is that the bias must be completely removed from the cores so that only the gate pulses themselves can determine the saturation and reset of each core. This is accomplished by using the control inputs as a blocking voltage to stop current from going through the bias winding. The standard bias supply is not used. Instead, the bias is supplied from 150 v dc original input power which is brought in at terminal 3. This is how it works: The bias is removed by applying a control input to terminals 1 or 2 which gives a voltage drop across resistor *C*. This voltage appears at the blocking rectifier, causing the bias current to flow through the Zener diode portion of the circuit as required to provide an alternate path for the bias current.

Logic-Element Power Supply: The last major component of a static control system is the power supply. This unit supplies all power required to operate the logic elements and the original input power. In the GE static control system, input power is 110 v, 60-cycle ac. A center-tapped transformer and rectifiers provide rectangular-shaped gate-voltage pulses which are applied to the gate windings of each magnetic-amplifier logic function. Another full-wave rectifier provides voltage across all of the bias windings which are placed in series with the rectifier output. If any of the bias windings open, the gate pulses are also interrupted because the bias windings are in series with the gate supply transformer primary.

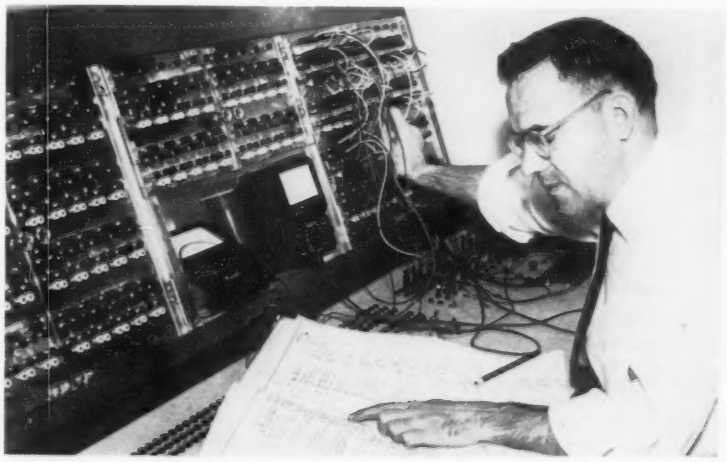
An adjustable resistor in series with the bias winding is used to adjust the bias current to the proper value for a specific number of logic elements. Also in series with the bias windings is a relay coil. This bias relay has two contacts one of which is put in series with the pulse power output in the power supply, Fig. 15.

This relay assures that bias is established to the logic element before gate pulses are applied when the system is first energized. Also, it protects against the possibility of an undesired half-cycle output under certain conditions. This condition could have arisen whenever system power was interrupted and certain elements were in the *on* condition at the time of interruption. If system power were to be restored so that a pulse or two could be generated before the bias could build up enough to reset the core, then an output could occur for a short period of time. The bias relay protects the system against this possibility. Also, if one of the rectifiers in the bias circuit should short out, the bias relay could not pick up, and pulse power could not be applied.

The other contact of the bias relay is used for interconnecting more than one power supply so that if bias in the elements supplied by one power supply fails, the whole system can be shut down. Undervoltage protection is also achieved in the same circuit.

Capacitor C1 is inserted in series with the gate and power supply to improve the strength of the gate pulse by using the principle of ferroresonance. A ferroresonant circuit is made up of an inductor with a saturable iron core and a capacitor.

To complete the power supply a full-wave rectifier with a 150 v dc output must be added to Fig. 15 across the line to supply original input power. This power is applied across limit switches, pushbuttons and other pilot devices and is then converted into a signal of proper voltage and current through resistor divider networks known as original inputs.



Author, Ed Rudisill, is shown checking out the design of static-control circuit on a simulator. This unit permits setting up a simulated machine-control circuit.

A 10-year G-E veteran, Ed has worked as a test engineer, servo development engineer, and application engineer on magnetic and static control systems.

Filtering

HYDRAULIC

By JAROSLAV J. TABOREK
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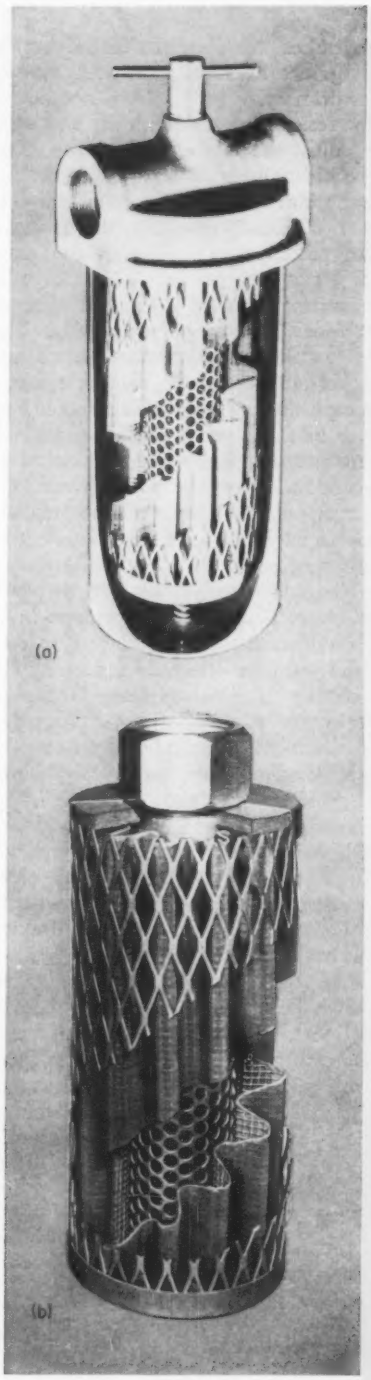


Fig. 6—Pleated mesh contained by cylindrical grids forms the cartridge of this wire-screen strainer. Contaminated oil enters between casing and cartridge. Screened oil leaves through cartridge center. In-line model, *a*, can be located anywhere in oil suction lines. Sump version, *b*, is mounted in oil reservoirs. Photos, courtesy Marvel Engineering Co.

ALL commercial filters operate on one or more of several general principles. Of these few, probably the most widely employed is mechanical filtration—physical retainment of solid contaminants in the labyrinth of a porous material through which fluid is passed. Other effective methods use the phenomena of adsorption, magnetism, centrifugal action, and distillation. This article does not elaborate on the latter two. Installations that use them are designed for very high flow.

Within the broad category of mechanical types, several subclasses are recognized, depending on the direction of flow through the filters and the distance that contaminants penetrate the filters. These groups are: Surface, edge, and depth-type filters.

Surface filtration derives its name from the use of filter elements that are functionally two-dimensional. Particles are retained on, not below, the filter surface. Pressure drop across surface filters is low, but

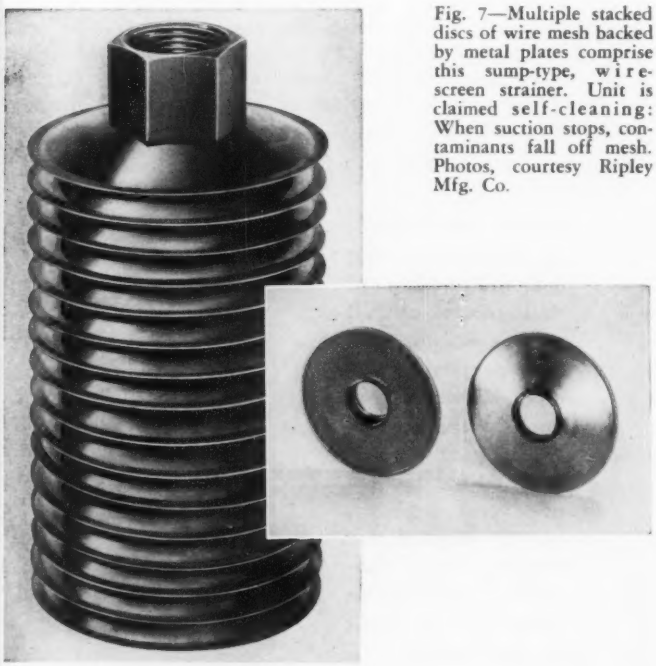


Fig. 7—Multiple stacked discs of wire mesh backed by metal plates comprise this sump-type, wire-screen strainer. Unit is claimed self-cleaning: When suction stops, contaminants fall off mesh. Photos, courtesy Ripley Mfg. Co.

CIRCUITS

Part 2

- *Filtration Principles*
- *Filter Types*

dirt absorption capacity is low, too. The latter is offset somewhat by the low cost of replaceable filter elements. Relatively coarse filters that employ the surface principle are wire-screen strainers. Other surface types, of finer grade, use paper or fabric membranes.

Wire-Screen Strainers

An important characteristic of wire-screen strainers is high specific filtration area—the area of openings in relation to the total filter area—which permits large flow capacities in relatively small units. Fineness of wire-screen filtration is limited mainly by economic considerations. Other filter types are competitive in price at mesh openings smaller than about 100 microns (No. 140 screen).

Generally, strainer screen is made of Monel wire. Fineness of the screen is designated by sieve or mesh numbers which are the approximate number of wires per inch of sieve length, Table 1.

Wire screens are easily damaged by careless maintenance and by fluid pressure. Good designs have strong wire mesh or similar protection on both sides of the screen.

Because the overall size of a strainer is often critical, an attempt is made to compress as much filtering area as possible into a small outside envelope. This is the objective in two different designs: 1. Longitudinally pleated or corrugated type, Fig. 6. 2. Stacked discs supported by sheet-metal cones, Fig. 7.

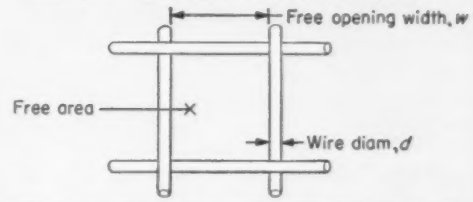
Wire strainers are most frequently used on the suction side of pumps. The location of mounting distinguishes two types:

Sump Types: Mounted directly in oil reservoirs, sump-type filters usually have a female pipe connection on the clean-oil exit port. The oil level should not be permitted to go below the screen level because the filtering area would be diminished and pressure drop increased. For large-volume flow, a parallel series of small units is used rather than single large ones.

In-Line Types: Although they can be located anywhere in suction lines, in-line type filters should be readily accessible for maintenance. The filter element itself is the same as for the sump type, but enclosed in a housing which permits the contaminated fluid to enter on the outside of the element and the clean fluid to leave on the inside, Fig. 6. Due to flow resistance through the housing, pressure drop across this type strainer is about twice that for the sump type. The price of the housing-enclosed strainer is also higher.

For both types, filter size in particular applications will depend on the acceptable pressure drop under the maximum probable oil viscosity, maximum flow volume, and the relation between degree of contamination and the desired frequency of maintenance. Correlations between pressure drop and flow volume should be supplied by manufacturers. This information is particularly useful in graph form, Fig. 8. If

Table 1—Standard Wire-Screen Data



Sieve or Mesh No.*	Wire Diam d (in.)	Free Opening Width, w (in.)	(micron)	Free Area† (per cent)
30	0.012	0.021	535	40.8
40	0.010	0.015	380	36.0
50	0.009	0.011	280	30.3
60	0.0075	0.009	230	30.5
70	0.0065	0.008	204	29.8
80	0.0055	0.007	178	31.4
100	0.0045	0.006	153	30.3
120	0.0037	0.0046	117	30.7
140	0.0029	0.0042	107	34.9
170	0.0024	0.0035	89	35.1
200	0.0021	0.0029	74	33.6

*Sieve No. $= 1/(d+w)$
†Free Area (per cent) $= 100\ (w \times \text{Sieve No.})^2$

no more accurate data are available, approximate values of free area per gpm flow are 3.5 sq in. per gpm for low capacities up to 10 gpm; 3 sq in. per gpm and 2.5 sq in. per gpm for capacities of 30 and 50 gpm, respectively.

The most frequently used and readily available mesh size is No. 100. Finer screens are commercially available up to No. 200 size, but are seldom seen in industrial applications. If such fineness of filtration is required, other filter types will be more suitable.

Surface-Type Filters

In fine-grade surface filters, the filter medium is a membrane of paper or fabric impregnated with phenolic resin, preformed into the shape desired, and cured at high temperatures. This treatment makes the medium water-proof, warp-proof, increases its rupture strength, and ultimately determines its porosity.

Free filtering area, as determined by porosity, is usually not great, so large surfaces are required to obtain reasonable flow volumes and acceptable service life. The accordian pleated design—the type most frequently used—provides effective filter area about seven times the surface of the enveloping cylinder, Fig. 9. In one development of particular interest, Fig. 10, the filtration surface is formed of stacked paper discs, every second one incorporating a pocket-type reservoir for contaminant storage.

Nominal fineness of membrane filters is in the order of 40 to 10 microns (0.0016 to 0.0004 in.). This becomes finer during operation, as pores become clogged, at the cost of additional pressure drop.

Moderate price makes membrane filters a good buy for fine filtration.

Fine-grade surface filters find applications under the following conditions:

1. Low operating pressure, in the order of several hundred psi.
2. Low to medium flow, if overall size must be limited.
3. Systems where high nominal fineness is a basic requirement; efficiency secondary.
4. Systems where the contamination content is not high and servicing of the replaceable cartridges is preferable.

Generally, surface-type filters are suitable for by-pass units. Another frequent application is air filtering in reservoir air breathers with particle retention of 40 microns. Surface-type filters have also been developed as suction line units. They provide a finer degree of filtration (down to 10 microns) for a lower price than corresponding wire screens.

Edge-Type Filters

Adaptability to high operating pressures and reusability of filter elements are the main common characteristics of edge filters. Separation of contaminants occurs as the fluid flows through small cir-

Fig. 8—Flow volume vs. pressure drop across filter for representative oil viscosities and filter grids. Line identifications include: Nominal filter size (5, 20, 50), free opening of the mesh (0.0035 in. = No. 170 mesh), oil viscosity in SSU (Saybolt Universal Seconds). Graph, courtesy Capital Engineering & Mfg. Co.

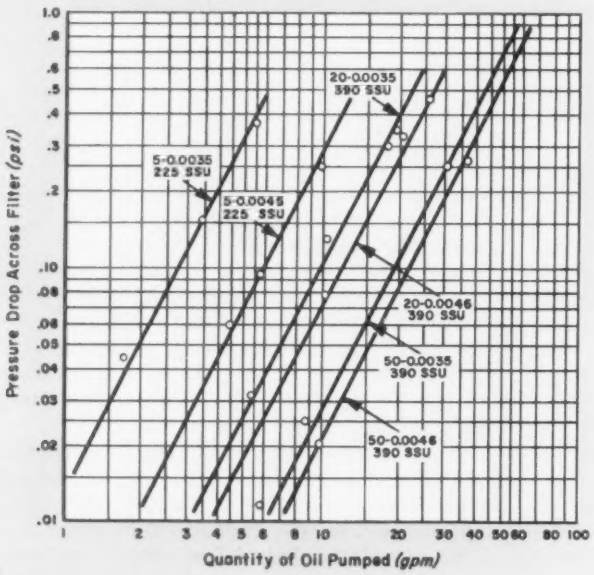
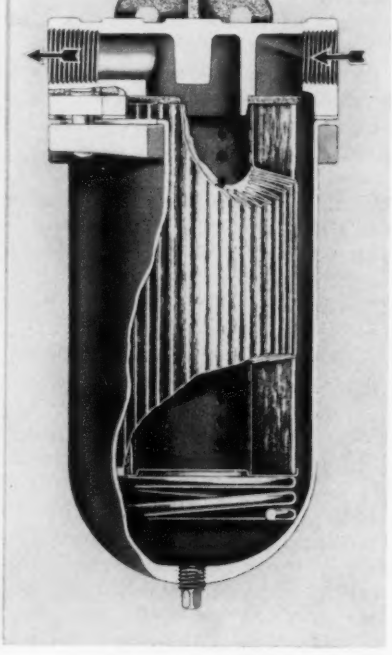


Fig. 9—Accordion-pleated, resin-impregnated, paper cartridge is commonly used for filtration fineness of 25 to 10 microns (0.001 to 0.0004 in.). Preferable application is in by-pass installations. Photo, courtesy Bendix Filter Div. of Bendix Aviation Corp.



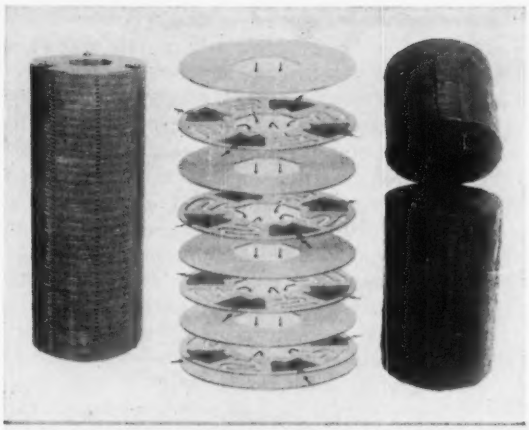


Fig. 10—Paper plates, alternately plain and perforated, comprise this fine-grade, edge-type filter. Contaminated oil is fed from outside the stack to pockets (shaded) which retain most contaminants. Thence, oil bleeds through paperboard to center channel, direct or via serpentine passages. Photo, courtesy Hilliard Corp.

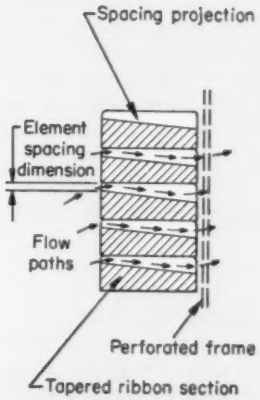
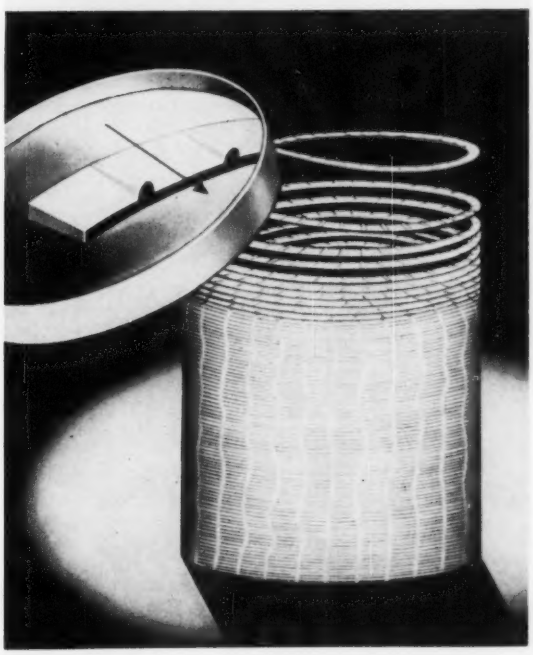


Fig. 11—In this metal-ribbon, edge-type filter, projections on the ribbon surface determine the size of openings and, hence, the filtration fineness. This type filters down to 40 microns (0.0016 in.). Tapered inward, the ribbon shape, in section, prevents wedging of contaminant particles. Illustrations, courtesy Purolator Products, Inc.



cumferential gaps in the edges of filter elements. The elements are compressed by a spring or tension bolts. Fluid enters from the ouside, contaminants larger than the gap are retained on the outer edge, and clean fluid leaves the element on the inside. Edge-type filters come in a variety of grades. Coarse types trap contaminants of 100 microns. Paper washer types filter down to 0.5 micron.

Types of construction include:

1. Alternately stacked metal discs and thin spacers.
2. Helically wound metal or impregnated paper ribbon having, across the width, small projections of controlled height which determine the width of the gap, Fig. 11.
3. Impregnated paper washers with radial corrugations.

Commercial, edge-type filters have the following combinations of characteristics:

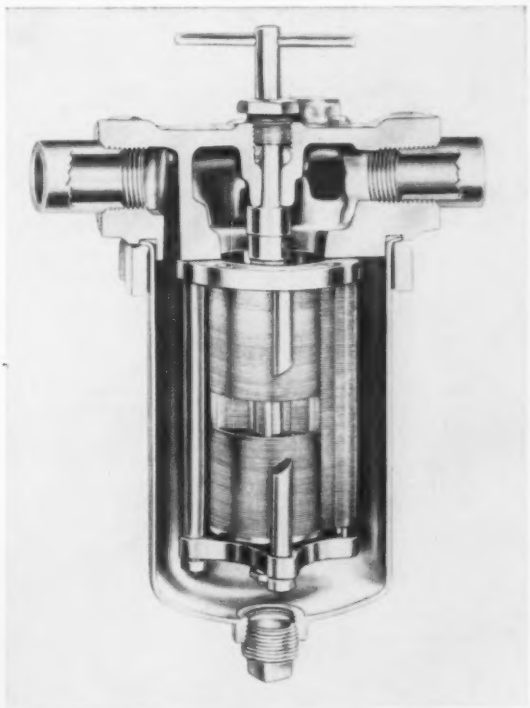
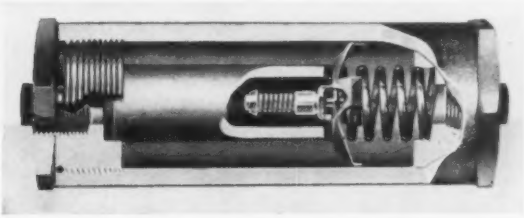


Fig. 12—Center shaft rotates in this edge-type filter, and thus draws filter stack past blades which scrape off coarse dirt. Accumulated sludge is drawn out casing plug hole. Photo, courtesy CUNO Engineering Corp.

Fig. 13—Cellulose ribbon is the filter medium in this in-line unit, designed for 25 gpm of SAE No. 10 oil at 100 F and 20 psi. Built-in relief valve opens at 80 psi pressure differential. Photo, courtesy Waterman Engineering Co.



Metal Ribbon and Metal Washer Spacer: Bronze, Monel or stainless steel are the usual materials for these filters. The metallic elements can be cleaned easily, even during operation of the system. Cleaning is done by scraper blades installed between the discs or by a scraper knife on the outside of the element. The accumulated dirt falls off and is collected in the housing sump from which it is drained occasionally. The cleaning mechanism can be operated automatically on a continuous basis, or manually at selected intervals, Fig. 12. Cleaning during operation is sometimes omitted on aircraft applications for safety reasons. Another method of cleaning is to reverse the flow briefly. Dirt is blown off the edges and accumulates in the filter sump.

Metal edge filters are most commonly available in fineness grades of 70 to 40 microns and in a wide variety of flow capacities. They can withstand extreme operating pressures and their flow rates are high. The price range is rather high, too.

Impregnated Paper Ribbon: Material used for elements of this type is cellulose impregnated with phenolic resin. The cleaning methods described for the metal types cannot be used for paper-ribbon type, but ribbon elements can be readily cleaned by flow reversal. They can also be disassembled, cleaned with a soft brush and solvent, and then reused several times. Their efficiency is not very high—about 90 per cent—because the regularity of the spacings is hard to control. Nominal commercial fineness is between 70 and 40 microns. Units operate under high pressures and at high flow rates, Fig. 13 and 14. Compared with metal-edge elements, the price of the paper-based units is low.

Cellulose Disc: This type is distinguished by the finest degrees of filtration. Grades reach 5, 2 and even 0.5 micron (0.0002 to 0.00002 in.). Their efficiency is also very high, up to 99 per cent. The combination of these properties makes them acceptable for critical applications such as fuel supply lines and sensitive hydraulic servosystems. Disc elements are cleanable, reusable, and will function at high operating pressures. Due to the high degree of filtration, only limited flow volumes can be handled.

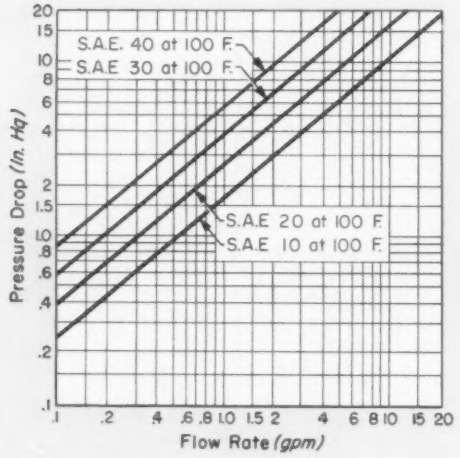


Fig. 14—Typical pressure-drop vs. flow-rate characteristics of a 1½ OD by 4-in. long cellulose-ribbon, oil filter element, 40-micron size. Pressure drop of complete filter, including housing and relief valve, is about twice the values shown for the filter only. Graph, courtesy Skinner Purifiers, Inc.

▶ Depth-Type Filters

In depth filtration, a fluid is forced through a thick layer of felt, compressed cotton, cellulose fibers, flannel, asbestos, or similar porous material. Struc-

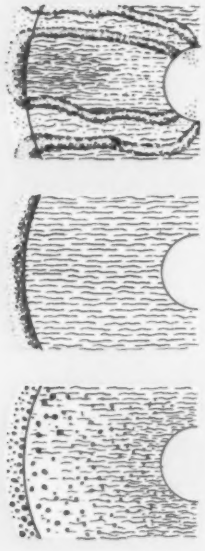
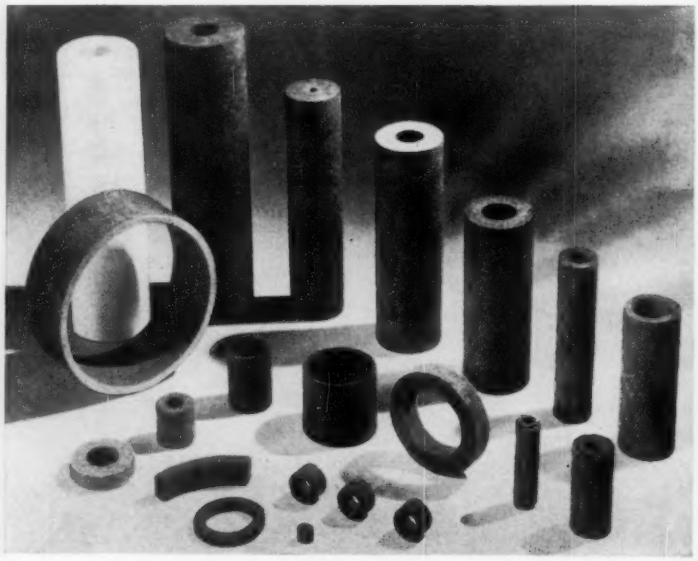


Fig. 15 — Faults in depth-type filter mediums: *a*. Uneven distribution of density and insufficient structural strength of the fibers cause "channeling" within the filter medium; results in uncontrollable fluid passages. *b*. Too high density of the filter medium causes dirt particles to accumulate on the surface; prevent filter functioning. *c*. Correctly constructed depth filter cartridge has density graded with depth. Sketches, courtesy CUNO Engineering Corp.

Fig. 16—One filter material, manufactured from impregnated cellulose fibers, can be formed into widely varied shapes. Photo, courtesy CUNO Engineering Corp.



ture and composition of the filter material must fulfill certain basic requirements.

The material must be strong enough not to rupture. If this happens, channels will form through the filter element and will pass particles much larger than the nominal degree of filtration. Fig. 15*a*.

Density of the filter medium and its distribution in depth should be such that dirt does not form a crust on the outer filter surface. If this happens, fine flow passages will clog rapidly and dirt absorption capacity will be greatly reduced. Pressure drop will increase and make frequent changes of the element necessary, Fig. 15*b*.

Good depth-type filter material is formed of resin-bonded cellulose fibers and has controlled density graduated from coarse to fine through the depth of the filter, Fig. 15*c*. Filter cartridges or elements are formed from fibrous material while in a pliable state. Thus, they can be worked into any desired form, size, or shape, Fig. 16. This particular property makes depth-type filters applicable in some cases where no other kind could be used.

While operating pressures are low—around 100 psi—and comparable to the surface-type filters, the main advantage of the depth-type filters is in their superior specific porosity, resulting in high absorption capacity and consequently longer service life. Filtration fineness is between 50 and 10 microns (0.002 to 0.0004 in.). Flow capacities range from fractional-gpm to large industrial units.

Filtration by Adsorption

While mechanical strainers and filters are capable of removing solid contaminants down to microscopic sizes, they are unable to separate the soluble oil-oxidation products. For complete purification of oil, removal of such contaminants as gums and varnishes is essential, for they adversely affect certain oil qualities such as viscosity and oiliness. They also promote sludge formation.

Separation of oil-soluble substances is possible through the adsorptive action of certain materials. *Ad*sorption is to be distinguished from *ab*sorption in that the adsorbed solute is attached to the *surface* of the adsorbent. In *ab*sorption, the contaminant penetrates *through* the absorbing agent and is retained mechanically.

The effectiveness of an adsorbent depends mainly on the exposed specific surface. Commercial adsorbents like fuller's earth, alumina, or bauxite have several hundred thousand square feet of specific surface per pound of substance.

Filters that function by adsorption pose two special problems:

1. Control of porosity, density and the structural strength of the material used.
2. Sensitiveness to water content in the oil with consequent danger of mud formation, and migration of particles into the fluid system.

Well-designed filter cartridges have the adsorbent bonded to a supporting material which increases the structural strength of the filter medium and permits

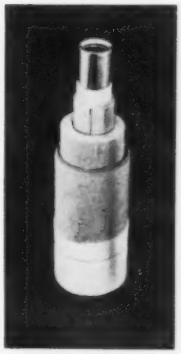


Fig. 17—From outside to core, a typical combination adsorbent and depth-type filter consists of sack cover, spirally-wound cellulose, activated adsorbent, another cellulose layer (to help prevent migration of particles from the adsorbent), and supporting wire screen. Photo, courtesy Briggs Filtration Co.

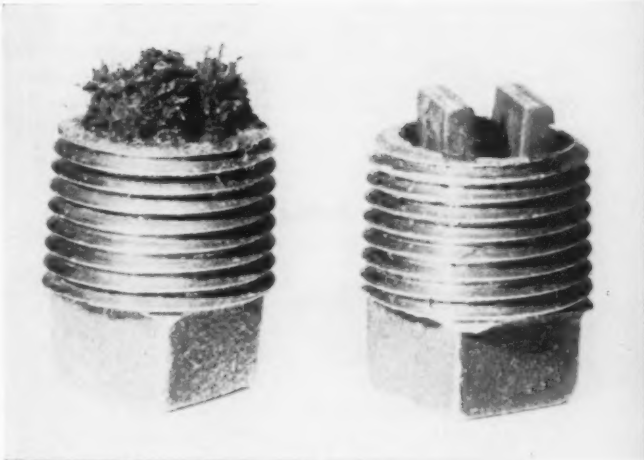
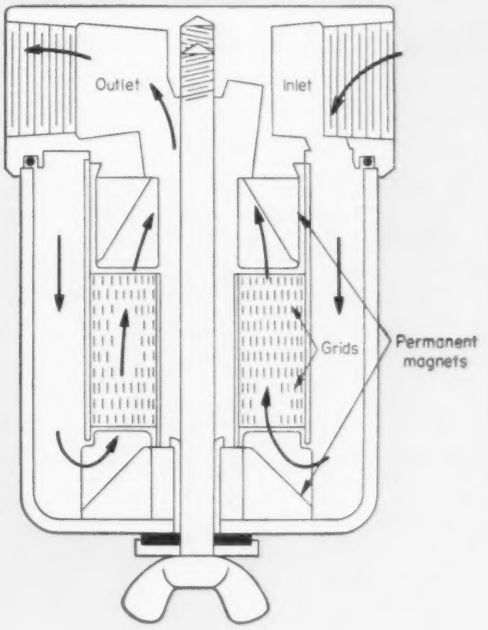


Fig. 18—Magnetic drain plugs are shown new, *a*, and saturated, *b*. Photo, courtesy Lisle Corp.

Fig. 19—Magnetic in-line filter, with housing, has a layer of steel grids enclosed between permanent magnets. Photo, courtesy S. G. Frantz Co. Inc.



density control. Furthermore, the adsorbent filter is often used in connection with a depth-type filter which removes the solid contaminants and retains particles of the adsorbent which otherwise migrate into the fluid system. The oil filtered through such a combination filter is refinery pure, Fig. 17.

Unfortunately, the adsorptive action removes not only contaminants but also soluble oil additives such as rust inhibitors. This property should be considered before adsorptive filters are specified. Often, the use of adsorptive filters is permissible after a certain initial run-in period in which the additives (e.g. rust inhibitor) have performed their function.

The most commonly used type, an adsorptive element combined with a depth-type filter, is especially suitable for handling highly contaminated fluids. Fineness of filtration is 10 microns or finer. Relatively high pressure drop, unavoidable in this type of filter, makes them acceptable for low-flow bypass installations. The water content of the fluid must be low to avoid disintegration of the adsorbent.

Filtration by Magnetism

Magnetic filters are true filters only in a limited sense, since they remove only contaminants having iron as a basic ingredient. Nevertheless, they are very effective purification devices in circuits in which wear products are a substantial part of the contaminants. Often, magnetic filters are used in conjunction with other filter types in the same circuit.

There are several types of magnetic units on the market:

Magnetic Drain Plugs: Probably the most common of magnetic filters, Fig. 18, magnetic drain plugs are to be found in nearly every properly equipped circuit. The reason for their popularity is their double purpose—drain plugs and filters. Plugs fitted with permanent magnets are not much more expensive than simple plugs which are needed in any case.

Special Magnetic Plugs: Unlike drain-plug combinations, special magnetic types perform no other function than particle removal. They can be located anywhere in reservoirs, but preferably where fluid circulation is high. Conversely, reservoirs should be designed for optimum flow past the plugs.

In-Line Magnetic Filters: This type approaches most nearly the conventional concept of a filter, Fig. 19. A layer of soft steel grids, strongly magnetized by permanent magnets, is enclosed in a housing. All the hydraulic fluid is continuously passed through this system and comes in much closer contact with the magnets than on plug-type installations. Correspondingly, the efficiency and the price of this installation are considerably higher than for plug installations.

Regular cleaning of all types of magnetic filters is essential, because high buildup of particles weakens attractive force and permits particles to be swept away by the fluid stream. Good practice calls for an initial cleaning after a run-in period of about 500 hours. Subsequent contamination will originate from wear of the circuit elements only. For this condition, a service period of around 5000 hours or one year should be sufficient.

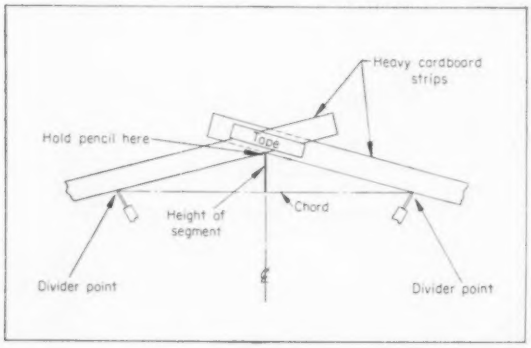
The next filtration article concludes this series of three. It gives the most important criteria for filter performance, and it describes types of filter installations in representative circuits.

Tips and Techniques

Drawing Arcs

An approximate but simple method of laying out arcs can be employed when extremely large radii are specified. When the chord length and radius are given, the height of the segments can be found.

Using the chord length as the base of the isosceles triangle and the segment height as the altitude, place two cardboard strips in the positions of the other two triangle sides. Tape the two strips together at their point of intersection, and insert a divider point at each end of the chord.



By holding a pencil at the intersection of the two cardboard strips and sliding them over the divider points, the required arc is obtained.—James D. Chapman, *Memphis, Tenn.*

Drawing Board Print

A print of a certain section or area of an assembly drawing can be obtained without removing the drawing from the board. Place a sheet of printing paper under, and a piece of glass over the desired area. Expose the area to a photo flood lamp in a hand reflector to produce the desired print.—Charles W. Bittner, *chief engineer, Precision Parts Co., Pennsauken, N. J.*

Layout of

Cones and Circular Segments

for maximum material economy

By A. M. WOODALL
Senior Design Engineer
Rust Engineering Co.
Birmingham, Ala.

DESIGN of circular segments, or segments of a fabricated cone, must be carefully matched to material requirements. Improper design may result in excessive costs because the design demands material that incurs mill extras or simply cannot be laid out to achieve maximum material utilization. For these reasons, layout of circular segments is important to the designer; he can check dimensions before the design is frozen. This data sheet gives the formulas necessary for finding dimensions of rectangles that will enclose various circular segments.

Layout: In applying the formulas, all dimensions should be taken on the centerline of the metal; cutting, burning and finishing allowances, if any, must be added to the calculated dimensions.

Of the methods given, one for doubling with maximum economy may not always be apparent until the layout elements are determined, Fig. 1. The experienced designer will then usually be able to narrow the proper choice to not more than two methods by inspection alone. Without exception, determination of these elements should be the first step in the calculations.

Since the methods presented are short and explicit, the sizes of required plates may be determined quickly with high accuracy; either natural or logarithmic functions may be used, at the option of the designer. However, it will be found that the employment of natural functions and a desk calculating machine will somewhat simplify the work and reduce the chances of error.

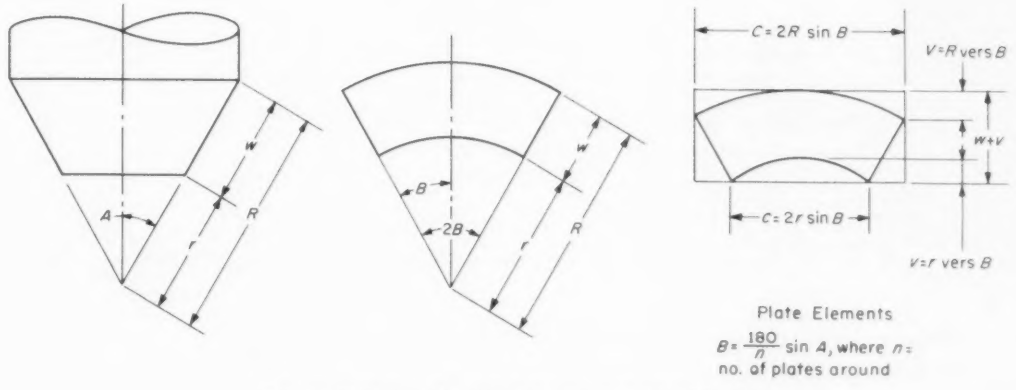


Fig. 1—Elevation, developed layout, and identification of plate elements for a segment of a cone surface

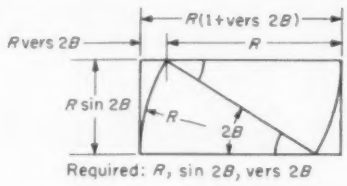
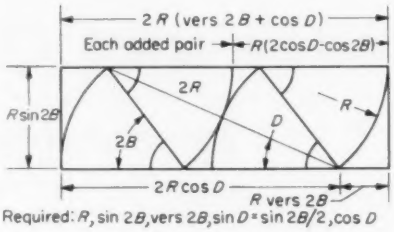
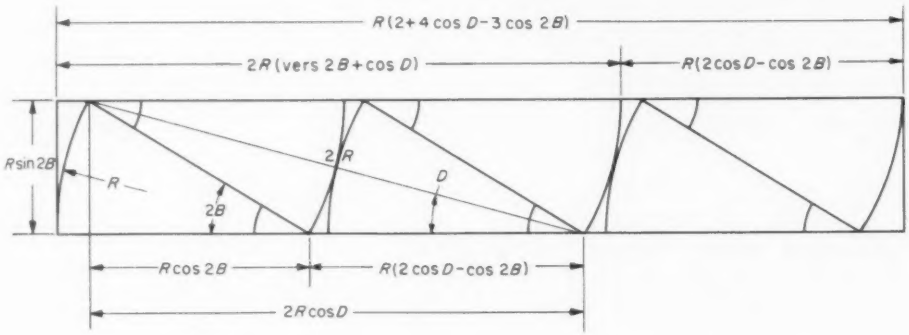


Fig. 2—Simple doubling of long slender segments provides good utilization of material

Fig. 3—Groupings of doubled layouts reduce scrap from corners of material





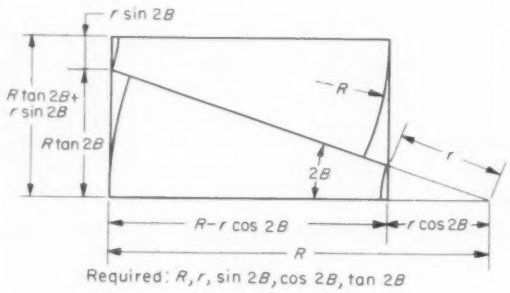


Fig. 4—Alternate layout for doubling on wider sheet or plate

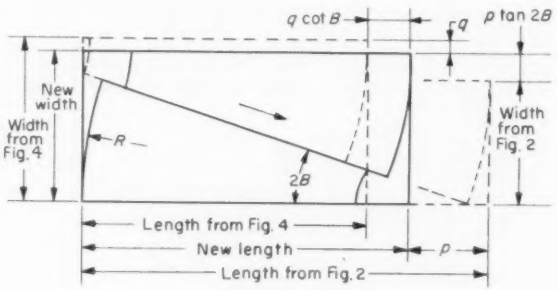


Fig. 5—Width or length can be adjusted to achieve maximum material economy

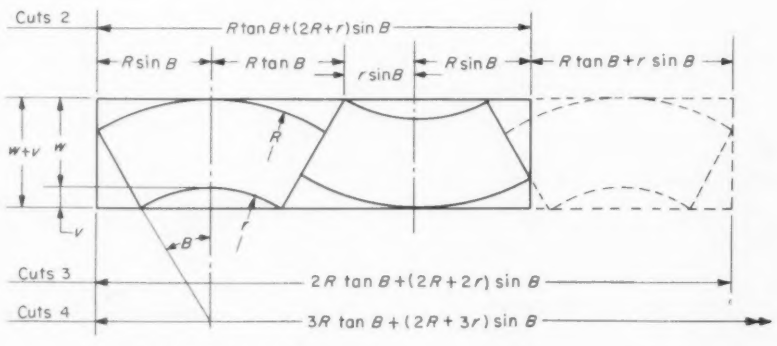
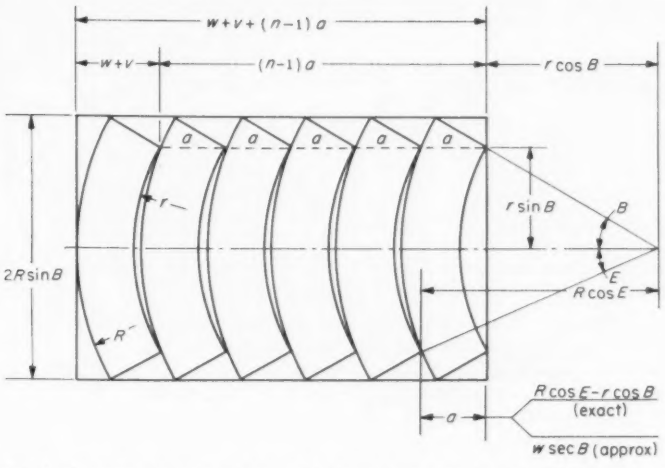
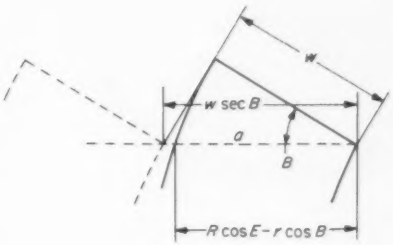


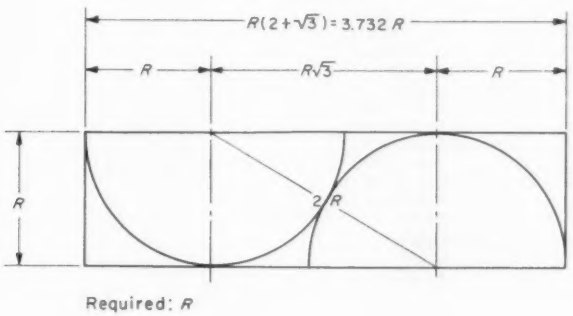
Fig. 6 — Layouts for doubling wide segments and for grouping



Required: n = no. of plates, R, r, w, v, sin B, cos B, sec B, sin $E = (r \sin B)/R$, cos E

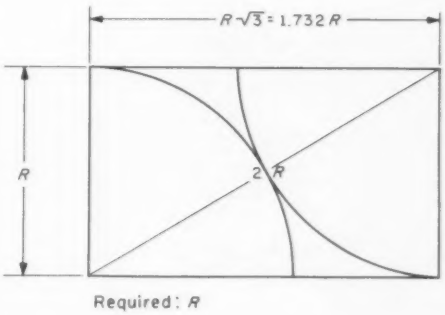
Fig. 7—Nested layout for wide, narrow segments. Use of approximation for a will not increase material scrap over 1 per cent unless included angle, $2B$, is relatively large





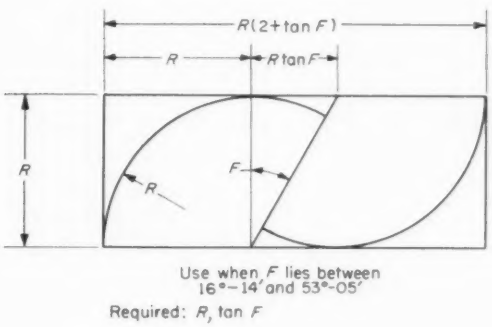
Required: R

Fig. 8—Layout for semicircles



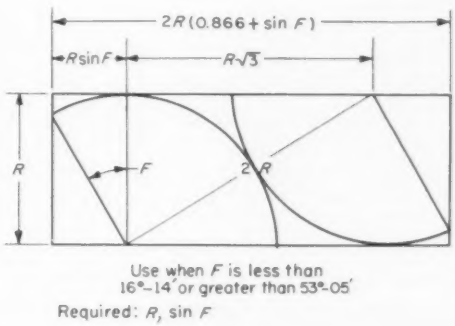
Required: R

Fig. 9—Layout for quadrants



Use when F lies between 16°–14′ and 53°–05′

Required: R, tan F

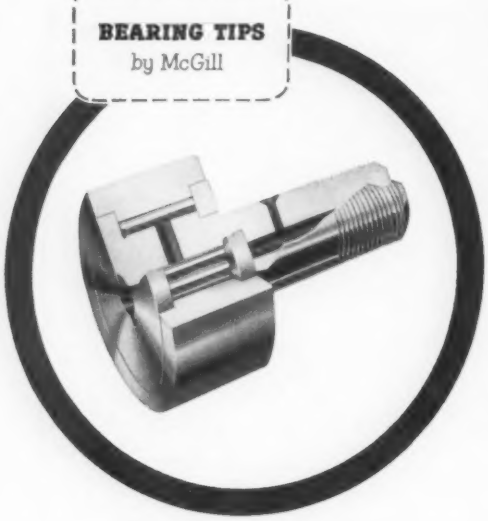


Use when F is less than 16°–14′ or greater than 53°–05′

Required: R, sin F

Fig. 10—Selection between alternate formulas depends on value of F

BEARING TIPS
by McGill



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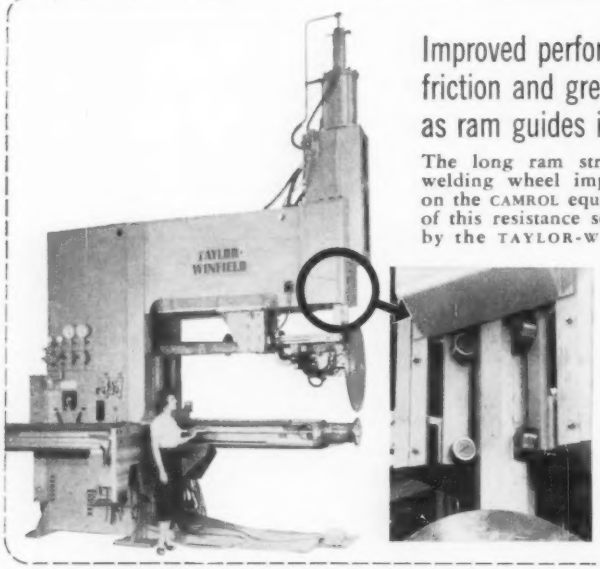

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The long ram stroke and large diameter welding wheel impose severe requirements on the CAMROL equipped ram guiding device of this resistance seam welder manufactured by the TAYLOR-WINFIELD CORPORATION. The CAMROLS provide greater accuracy with less friction than was experienced with a round ram and bushing type bearing formerly used. Lubrication is simplified, maintenance reduced and performance is excellent.

The welder has a throat depth of 84" and a 12" vertical stroke of the upper ram carrying the large diameter welding wheel.

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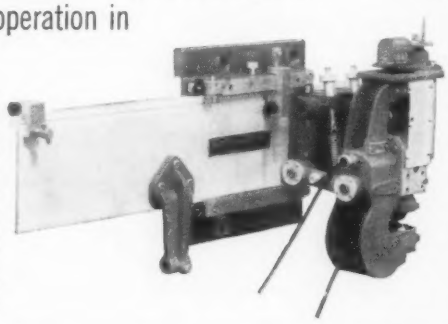

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Circle 476 on Page 19

DESIGN ABSTRACTS

electrical

Design Limitations Of Semiconductor Components

P. D. Ankrum, Hughes Aircraft Co.

A discussion of diode design limitations including the forward and reverse conduction characteristics of the p-n junction. Characteristics of breakdown voltage, reverse saturation current, junction capacitance, the diode equation, and contact spreading resistance are included. Factors influencing the operation of junction transistors are considered and some design limitations discussed.

AIEE Proceedings of the 1958 Electronic Components Conference, *pp.* 35-41.

Component Application Stress Analysis

John A. Connor, Hughes Aircraft Co.

An analogy between the engineering use of structural materials and the application of electronic components. Stress-strain relationships for component usage take the form of statistical failure characteristics. It is shown how the application of a part is accompanied by a level of risk consistent with circuit function accomplished, just as a reasonable strain is accepted in a structural stress member. The analytical utility of such failure-rate data is described.

AIEE Proceedings of the 1958 Electronic Components Conference, *pp.* 101-115.

Multiconductor Flat Wire Cable

S. J. Stein and A. L. Pugh Jr., International Resistance Co.

A description of the multiconductor flat wire cable as a new approach toward space saving and miniaturization. Physical and electrical properties and techniques of insulation stripping, soldering, connecting, branching, shielding, and mounting for repeated flexing are discussed. Possibilities of using insulation capable of withstanding high temperatures are covered.

AIEE Proceedings of the 1958 Electronic Components Conference, *pp.* 213-222.

The Controlled Rectifier

J. D. Harnden Jr., General Electric Co.

A discussion of the basic characteristics and functions of the controlled rectifier. Comparisons are made between the controlled rectifier and other competitive control devices such as power transistors, magnetic amplifiers, and thyratrons. Applications of the rectifier for control of heaters, control of lamps, motor and generator control, static switching, and static excitation are outlined.

AIEE paper "The Controlled Rectifier —Key to the Continuing Controlled Renaissance," Special Technical Conference on Nonlinear Magnetics and Magnetic Amplifiers, Los Angeles, August, 1958; 16 *pp.*

Transistors and Reactors In a High-Pressure Servo

F. B. Cox Jr. and P. R. Johannssen, MIT

A discussion of how performance of instrument servos can be improved by exclusive use of magnetic devices and transistors to perform the function of amplification, modulation, and demodulation. It is shown how substitution of solid-state devices for electronic amplifiers and mechanical choppers increases efficiency, reliability, and durability of the system and also minimizes its size and weight.

AIEE paper CP 58-89, AIEE Pacific General Meeting, Sacramento, Calif., August, 1958; 19 *pp.*

Solving Thermocouple Protection Problems

A discussion of the advantages of magnesium oxide swaging tubes of various sizes for thermocouple protection at high temperatures. Thermocouple response time and critical diameters are mentioned.

Carborundum's Advanced Materials Technology, *Vol.* 1, *No.* 3, 1958; 1 *p.*

materials

Materials for Electrical Systems In High-Temperature Aircraft

D. K. McIlvaine, Westinghouse Electric Corp.

A discussion of the effects of high temperature and thermal stresses on materials for aircraft electrical systems. Data are included for high-tensile, low-creep metal and alloys, various insulations, and semiconductor materials. Magnetic materials, copper conductors, high purity silver, and aluminum are also considered.

AIEE paper 58-843, *from AIEE Summer General Meeting, Buffalo, June* 1958; 14 *pp.*

Metal Powders in Missile and Rocket Fuels

L. R. Frazier, Metal Hydrides Inc.

A discussion of the properties of certain powder metals which make

these metals suitable for possible rocket fuels. Beryllium, lithium, and boron are among elements covered. Various ways in which metal powders are used as fuels and their specific advantages are discussed.

MPIF paper, MPA 14th Annual Meeting, Philadelphia, April, 1958; 14 pp.

New Industrial Tools Utilizing Phosphors

C. W. Wallhausen, U. S. Radium Corp.

A report on two specific developments in phosphors which have immediate industrial application. Developments are the self-luminous light sources and thermographic phosphors. Tests show that glowing surfaces could be used as an indication of temperature changes by either extinction of the glow or by a sudden visual glow of the phosphorous surface. Desirable features of these compounds are covered, and development of phosphors for inspection work are discussed.

SAE paper 53C, from SAE Summer Meeting, Atlantic City, June, 1958, 6 pp.

High-Temperature Electrical Insulation

R. N. Evans, Wright Air Development Center

A review of WADC development of high-temperature electrical materials. Electrical materials include those used in the fabrication of wire and cable insulation, capacitor dielectrics, interlayer and magnet wire insulation for transformers, subassembly encapsulation, radomes, resistors, and base plates for printed circuits. Included is a list of commercially available electrical materials for high-temperature applications together with temperature limitations.

AIEE paper 58-835, from AIEE Summer General Meeting, Buffalo, June 1958; 7 pp.

Fire-Resistant Hydraulic Fluids

C. E. Francis and R. T. Holmes, Shell Oil Co.

A report on fire-resistant hydraulic fluids and resultant improved performance of hydraulic components. Effects of fluid properties on wear characteristics of pumps are covered.

ASLE paper 58AM 6C-1, "Emulsion-Type Fire-Resistant Hydraulic Fluids—New Developments Reflect Improved Performance," from ASLE 13th Annual Meeting, Cleveland, April, 1958; 14 pp.

Material Selection For Mechanical Seals

H. Hummer, Dura-Metallic Corp.

A discussion of materials and combinations of materials for specific sealing applications. Characteristics of the material combinations and physical properties of the materials are evaluated with respect to various operating fluids. Materials include solid ceramics, Stellite, bronze and tungsten carbide.

ASLE paper 58AM 1A-3, from ASLE 13th Annual Meeting, Cleveland, April, 1958; 5 pp.

Plastic Flow and Fracture of Gray Cast Iron

B. Crossland and W. H. Dearden, University of Bristol, England

A report of tests conducted on gray cast iron to investigate plastic flow and ultimate failure, and in particular torsion tests carried out with superimposed fluid pressure to 79,000 psi.

From "The Plastic Flow and Fracture of a Brittle Material (Gray Cast Iron) with Particular Reference to the Effect of Fluid Pressure," prepared for the Institution of Mechanical Engineers, Westminster, London; 12 pp.

mechanical

Matching Turbochargers To High-Speed Diesel Engines

W. E. Parker, The Garrett Corp.

A consideration of factors which affect selection of the turbocharger. Design features and function of the turbocharger are explained. Engine characteristics are related to turbo performance and evaluated to aid in matching the components.

SAE paper 71C, from SAE National West Coast Meeting, Los Angeles, August, 1958; 9 pp.

Fundamentals of Lubrication

M. D. Hersey, U. S. Naval Engineering Experiment Station

Fundamental principles of lubrication reviewed as a background for research. Topics covered include the principle of the converging film, lubrication of parallel surfaces, dynamically loaded bearings, physical properties of lubricants, theory of fluid film lubrication, and thin-film lubrication.

Bureau of Ships Journal, Vol. 7, No. 2, June, 1958; pp. 7-8.

Fatigue Strength Of Pin-Jointed Connections

A. C. Low, M.E.R.L., East Kilbride, Glasgow

A report on the results of an investigation to improve the fatigue strength of pin-jointed assemblies in aluminum alloys. Fatigue strength is shown to be improved by use of interference fits between pin and lug specimens tested. Effect on strength of variations in pin diameter is included.

From "The Fatigue Strength of Pin-Jointed Connections in Aluminum Alloy B.S. L65," prepared for the Institution of Mechanical Engineers, Westminster, London.

Application Of Powder Metal Gears

Applications and characteristics of a wide variety of gears made by powder metallurgy techniques. Types include spur, bevel, face, cluster, skip-tooth, and helical gears. Materials covered are bronze, brass, iron, and prealloyed steel powders. A separate section discusses the properties and characteristics of materials used in gears for highly stressed service.

MPIF Powder Metallurgy Quarterly, *Spring, 1958; 5 pp.*

TO OBTAIN COPIES of papers or articles abstracted here, write directly to the following organizations:

AIEE—American Institute of Electrical Engineers, 33 West 39th St., New York 18, N. Y.; papers 40 cents to members, 80 cents to nonmembers.

Advanced Materials Technology, The Carborundum Co., New Products Branch, Research & Development Div., Niagara Falls, N. Y.

MPIF—Metal Powder Industries Federation, 130 W. 42nd St., New York 36, N. Y.

SAE—Society of Automotive Engineers Inc., 485 Lexington Ave., New York 17, N. Y.; papers 50 cents to members, 75 cents to nonmembers.

ASLE—American Society of Lubrication Engineers, 84 East Randolph St., Chicago 1, Ill.; papers 35 cents to members, 50 cents to nonmembers.

The Institution of Mechanical Engineers, 1 Birdcage Walk, Westminster, London, SW 1.

Bureau of Ships Journal, Bureau of Ships, Department of the Navy, Washington 25, D. C.

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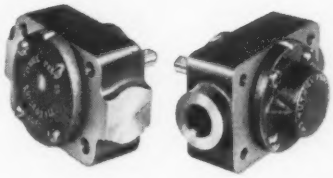

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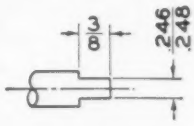
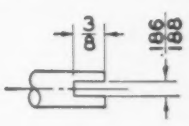


MODIFICATION "A"



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d. Pumps with *variations* of both internal and external porting

4. TUTHILL Catalog Section 108 contains line drawings showing each model in detail, shaft rotation and porting arrangements and other vital statistics to help you select the RIGHT model. Fill out the attached coupon—or write.

TUTHILL PUMP COMPANY
953 East 95th Street, Chicago 19, Illinois
Gentlemen:
☐ Please send me Catalog Section #108
☐ Please send the complete catalog on the Tuthill line
☐ Have your representative call

NAME_____ TITLE_____
COMPANY_____
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CITY_____ ZONE____ STATE_____

Tuthill Manufactures a Complete Line of Positive Displacement Rotary Pumps in Capacities from 1 to 200 GPM, for Pressures to 600 PSI, Speeds to 3600 RPM.

TUTHILL PUMP COMPANY
953 East 95th Street, Chicago 19, Illinois
PUMPS FOR YOUR PURPOSE

Circle 477 on Page 19

Helpful Literature

for Design Executives

For copies of any literature listed, circle Item Number on Yellow Card—page 19

Milling Techniques

An unusual continuous milling process and a new sculpture milling technique are described in Form 5-458. The variety of parts produced by these milling techniques are shown. Milling capacities range up to 20-ft table travel. 8 pages. Precision Shapes, Inc., Suffern 2, N. Y. D

Circle 601 on Page 19

Instrument Photoprints

Company is offering ¼-scale photoprints of its instrument line to designers concerned with instrumentation layout. Accurate picture of proposed control panel can be made up with a cut-out, paste-on technique using the photoprints. Bristol Co., Waterbury 20, Conn. B

Circle 602 on Page 19

Cartridge Ball Bearings

Bulletin 104 describes Hoover cartridge ball bearings and tabulates specifications and radial load ratings. Bearings feature dual labyrinth seals which assure long bearing life. 4 pages. Hoover Ball & Bearing Co., Ann Arbor, Mich. H

Circle 603 on Page 19

Aluminum Structural Shapes

Angles, channels, flat and bar stock, square tubing, I-beams, track, and double channels are included among the 163 sections of extruded aluminum structural shapes illustrated in catalog. Sections are shown in actual size. 12 pages. Youngstown Mfg., Inc., 66-76 S. Prospect St., Youngstown, Ohio. G

Circle 604 on Page 19

Stainless Steels

Physical properties and analyses, corrosion and heat resistance, surface finishes, fabrication, maintenance, and bacterial cleanability of Microrold special purpose stainless steels are among data presented in booklet. Sheet and strip grades are offered. 28 pages. Washington Steel Corp., Washington, Pa. G

Circle 605 on Page 19

Magnetic Toggle Relay

A polarized, bi-stable relay with a binary memory, the magnetic toggle relay is described and illustrated in a folder which contains its specifications, construction and design features, and typical applications. 4 pages. American Electronics Co., 2801 37th Ave. N.E., Minneapolis 18, Minn. J

Circle 606 on Page 19

Fluid Line Couplings

Two illustrated folders (AR-010 and AR-015) present design data, specifications, and ratings for Roylyn quick couplings for fluid lines. Open and self-sealing types are offered in various pressure ratings, metals, and finishes. 4 pages each. Airaterra, 620 Paula Ave., Glendale 1, Calif. L

Circle 607 on Page 19

Lubrication Systems

Ram-Pump centralized power lubrication systems for low and high pressure applications are detailed and illustrated in Bulletin 812. Applications and advantages are covered, as are controls and accessories for automated systems. 4 pages. Lincoln Engineering Co., 5736 Natural Bridge Ave., St. Louis 20, Mo. I

Circle 608 on Page 19

Hard Rubber Fittings

Natural hard rubber and Buna N synthetic rubber pipe fittings and valves are described in illustrated Bulletin PF 1300. Characteristics and handling data, diagrams and dimensions of products are given, along with material properties. 8 pages. Luzerne Rubber Co., Trenton, N. J. D

Circle 609 on Page 19

External Cotter Pins

Fifteen standard external or "hairpin" cotters are described on Data Sheet 301-EC. Prices, dimensions (including wire size), pin diameters, and lengths are given. 1 page. Hunter Spring Co., 1 Spring Ave., Lansdale, Pa. E

Circle 610 on Page 19

Shaded Pole Motors

Information on unidirectional, nongeared, alternating current, shaded-pole motors presented in illustrated Catalog U-1 includes duty cycle, power sources, variations, braking, controls, ratings, dimensions, and applications. Five motor types are covered. 8 pages. Barber-Colman Co., Rockford, Ill. K

Circle 611 on Page 19

Air-Over Motors

Line of totally enclosed Tri-Clad 55 air-over motors from 7½ to 100 hp is subject of descriptive Bulletin GEA-6598. Used for propeller and axial flow fans, these motors are as much as 20 per cent smaller and 30 per cent lighter than previous models. 4 pages. General Electric Co., Schenectady 5, N. Y. C

Circle 612 on Page 19

Control System Components

Digitrol building blocks, subject of illustrated folder, provide an easy means of assembling control systems and permit combination analog and digital systems. Available types are outlined and their uses listed. 4 pages. Electro Precision Corp., Box 669, Arkadelphia, Ark. A

Circle 613 on Page 19

Bearing Bronze

Sabeco bearing bronze which cannot burn, pound out, score, or seize the shaft is subject of pocket-size illustrated folder. Its composition and applications are covered. Five grades are offered, as are replacement thrust washers. 6 pages. Saginaw Bearing Co., 821 S. Water St., Saginaw, Mich. H

Circle 614 on Page 19

Voltage Regulators

Standard line of Stabiline Type EMT automatic voltage regulators is described in illustrated Bulletin S358EMT. All types feature a transistorized control circuit that detects changes in output voltage and supplies correction voltage. Units are rated from 2 to 100 kva. 12 pages. Superior Electric Co., Bristol, Conn. B

Circle 615 on Page 19

Insulating Varnish

Relative factors of units viscosity, temperature-viscosity relations in varnishes, reduction of viscosity in varnishes, and a temperature conversion chart are included on plastic-finished, 11 x 14-in. Insulating Control Chart. Westinghouse Electric Co., Micarta Div., Manor, Pa. F

Circle 616 on Page 19

Rack & Panel Connectors

Series DTX rack and panel connectors for military and industrial applications are described in bulletin. Nineteen contact arrangements are illustrated. Design permits large number of contacts in a relatively small area. 4 pages. H. H. Buggie, Inc., Box 817, Toledo 1, Ohio. G

Circle 617 on Page 19

Pumps, Fluid Motors, Valves

Basic information on internal gear, sliding vane, and spur external gear pumps, fluid motors, and relief valves is contained in Catalog 100. Powermite pump and motor combinations and Powermax fluid motors are also detailed. A pump selection guide is included. 12 pages. Tuthill Pump Co., 953 E. 95th St., Chicago 19, Ill. J

Circle 618 on Page 19

Electrical Insulation

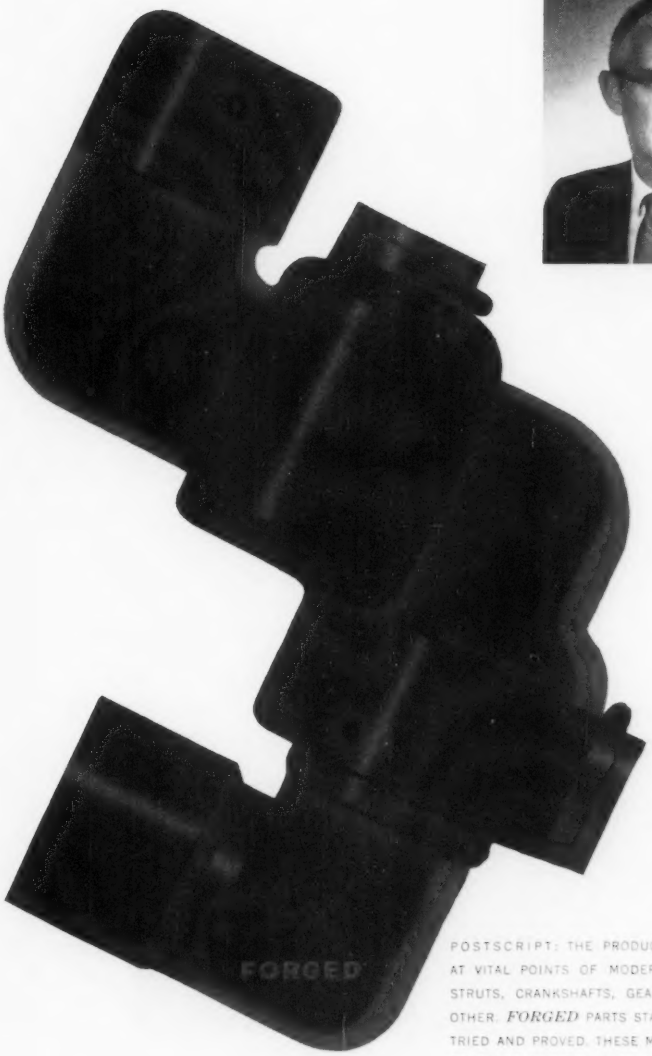
Details of Armite and Spauldo thin electrical insulations are given in bulletin. Their properties, characteristics, and uses are covered. 4 pages. Spaulding Fibre Co., 310 Wheeler St., Tonawanda, N. Y. N

Circle 619 on Page 19

FORGED Parts

are Free from Inside Faults

—sound from center to surface



"There's an 'inside story' to the forged parts we use for swivel joints on steel hose for oil producers. These joints work at pressures up to 15,000 lbs. per sq. in., temperatures to 600° F., and handle abrasives such as mixtures of oil and sand, and wet cement. Under such tough conditions the *forged* joints prove tight against leakage, safe against bursting, and have lasted for many years in such service. This remarkable durability is possible because the forged metal is sound, dense, non-porous *from center to surface.* Freedom from inside faults also saves production dollars; when we cut into the forged parts to machine precise, expensive ball-bearing races and accurate mating surfaces, we do not find inside faults that would cause rejections. Any way you look at it, this inside story helps us and our customers."

G. M. BAGNARD
Chief Engineer,
Chiksan Company, makers of swivel joints, rotary hose, mud mixing guns.
(Subsidiary of Food Machinery and Chemical Corporation)

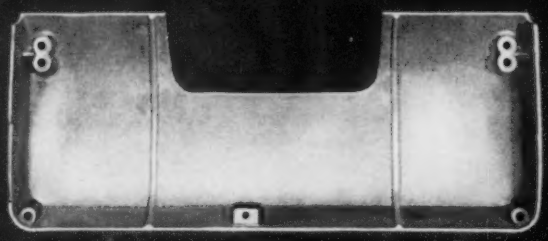
POSTSCRIPT: THE PRODUCTS OF THE FORGING INDUSTRY ARE FOUND AT VITAL POINTS OF MODERN CONVEYANCES AND MACHINES...LEVERS, STRUTS, CRANKSHAFTS, GEARS. THE FORGING PROCESS IS UNLIKE ANY OTHER. *FORGED* PARTS START WITH REFINED METALS—METALS ALREADY TRIED AND PROVED. THESE METALS ARE GIVEN ALMOST ANY DESIRED FORM OR SHAPE BETWEEN IMPRESSION DIES, UNDER ENORMOUS PRESSURE OR BY CONSECUTIVE BLOWS FROM POWERFUL HAMMERS. THE RESULT IS ADDED STRENGTH AND TOUGHNESS...WHICH PERMITS WEIGHT-SAVING DESIGNS, CUTS SERVICE COSTS, HELPS PROVIDE SAFETY IN A HIGH-SPEED WORLD.

DROP FORGING ASSOCIATION · 55 Public Square · Cleveland 13, Ohio

COMPOSED OF THE INDEPENDENT COMPANIES PRODUCING THE MAJOR SHARE OF COMMERCIAL FORGINGS IN THE UNITED STATES & CANADA

Circle 478 on Page 19

Die Castings Cut 10 Pounds off Frameweight of New Royal Standard



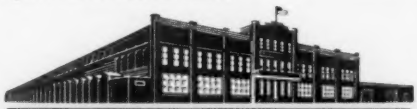
CASE HISTORIES FROM MT. VERNON FILES

"Never before has a standard typewriter featured so many new improvements. From Twin-Pak to Touch, this new Royal Standard opens up a whole new world of breathtaking ease and economy." It is a fine example of beautiful design, excellent engineering and wise choice of materials.

Because of the remarkable strides made by the die casting industry in the production of sound economical aluminum die castings, the major portion of the framework of all the Royal Typewriters are die cast. Through the use of aluminum die castings having cored holes, close tolerances and thin walls ribbed for maximum strength, Royal engineers have reduced the weight of the framework of the Standard model from 15 pounds to approximately 5 pounds . . . an impressive savings of 10 pounds.

All told, the Royal McBee Corporation uses from 2½ to 3 million pounds of aluminum die castings yearly and the end of die casting usage is not in sight. Royal engineers are constantly alert to additional die casting applications because of the tremendous savings in man and machine hours which are achieved through the elimination of costly secondary operations.

A switch to die casting may be *your* next step. It will be well worth your time to bring your product specifications to Mt. Vernon, for ours is a complete, four-fold service of 1. Consultation 2. Die making 3. Die casting 4. and Machining facilities all under one roof occupying 200,000 square feet of space . . . For quick action, contact your nearest sales representative listed below.



MT. VERNON
DIE CASTING CORP.
STAMFORD, CONNECTICUT

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STAMFORD, CONN.: Mr. Anker Anderson, Cascade Road
VALLEY FORGE, PA.: Mr. G. T. McMaster, P.O. Box 115

Circle 479 on Page 19

Pump Motors

Instruction Manual F-1949 covers installing, inspecting, and servicing of Vertiglosed pump motors of both the oil-lubricated and grease-lubricated type. Instructions detail mounting, oil-fill, electrical connection, mechanical connection, and the use of upthrust protection. Trouble-shooting chart is included. 24 pages. U. S. Electrical Motors Inc., Box 2058, Los Angeles 54, Calif. L

Circle 620 on Page 19

Mechanical Tubing

How savings in time, material, and money can be realized on machining and fabricating operations with seamless carbon steel mechanical tubing is related in illustrated Bulletin TB-418. It explains how production can be simplified by selection of the proper tubing type. Tubing tolerance tables are included. 6 pages. Babcock & Wilcox Co., Tubular Products Div., Beaver Falls, Pa. G

Circle 621 on Page 19

Bronze Bearing Alloys

"Chemical and Physical Specifications of the Bronze Alloys" is title of brochure which gives alloy or ingot number, grade, and properties of 24 alloys most commonly used for bushings and bearings. It also lists various comparative specifications. 4 pages. Renewal Service, Inc., 17th & Lehigh Avenue, Philadelphia 32, Pa. E

Circle 622 on Page 19

Air Line Equipment

Catalog 157 describes a line of automatic moisture separators, lubricators, regulators, filters, and filterators for compressed air systems. Products for automatic filtration of oil, oil fumes, and solid contaminants are also covered. Wilkerson Corp., 1646 W. Girard Ave., Englewood, Colo. K

Circle 623 on Page 19

Spring Wire

Special HB machinical spring wire, made to extremely close tolerances, is subject of Bulletin DH-107A. It is dry drawn to about music wire tensile strengths. Properties, sizes, finishes, and other data are presented. 4 pages. American Chain & Cable Co., Page Steel & Wire Div., Monessen, Pa. B

Circle 624 on Page 19

Phosphating Analysis

Metalworking manufacturers can determine whether their products are adaptable to phosphating and the paint adhesion advantages it offers by use of a phosphating analysis kit. Turco Products, Inc., 6135 S. Central Ave., Los Angeles 1, Calif. L

Circle 625 on Page 19

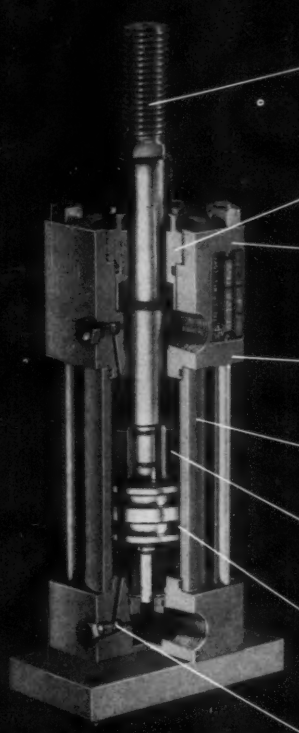
Coated Magnet Wire

Magnet wire coated with a modified silicone material is suitable for Class B, F, and H insulation systems. The Sylkyd enameled wire's properties, uses, and advantages are outlined in Bulltin 10-404. 4 pages. Dow Corning Corp., Midland, Mich. H

Circle 626 on Page 19

for performance...
dependability...
economy... specify SP

HEAVY DUTY AIR and HYDRAULIC CYLINDERS


hardened oversize rod—maximum rigidity—resists scoring and nicking
easily removed cartridge-type rod seal with integral rod wiper
ferrous parts rust-proofed to prevent corrosion
steel end plates for strength and positive alignment
precision-honed seamless steel tube
floating cushions—uniform cushioning—long life—fully adjustable
low-friction block-vee piston seals or piston rings optional
springless ball checks for faster action

Rated 200 psi air or 1,000 psi hydraulic—interchangeable air or hydraulic without modification—built to JIC standards—specified by automotive manufacturers—conforms to Ford and Chrysler standards.

If your service requirements are severe . . . if you need uniform operation, long trouble-free life, minimum equipment downtime . . . you need S-P heavy-duty air and hydraulic cylinders!

Want more proof? A phone call will bring our representative on the run! Prompt deliveries, too. The S-P Manufacturing Corporation, 30201 Aurora Road, Solon, Ohio.

SP for speed and performance

Representatives in principal cities. Phone or write for Catalog No. 115.

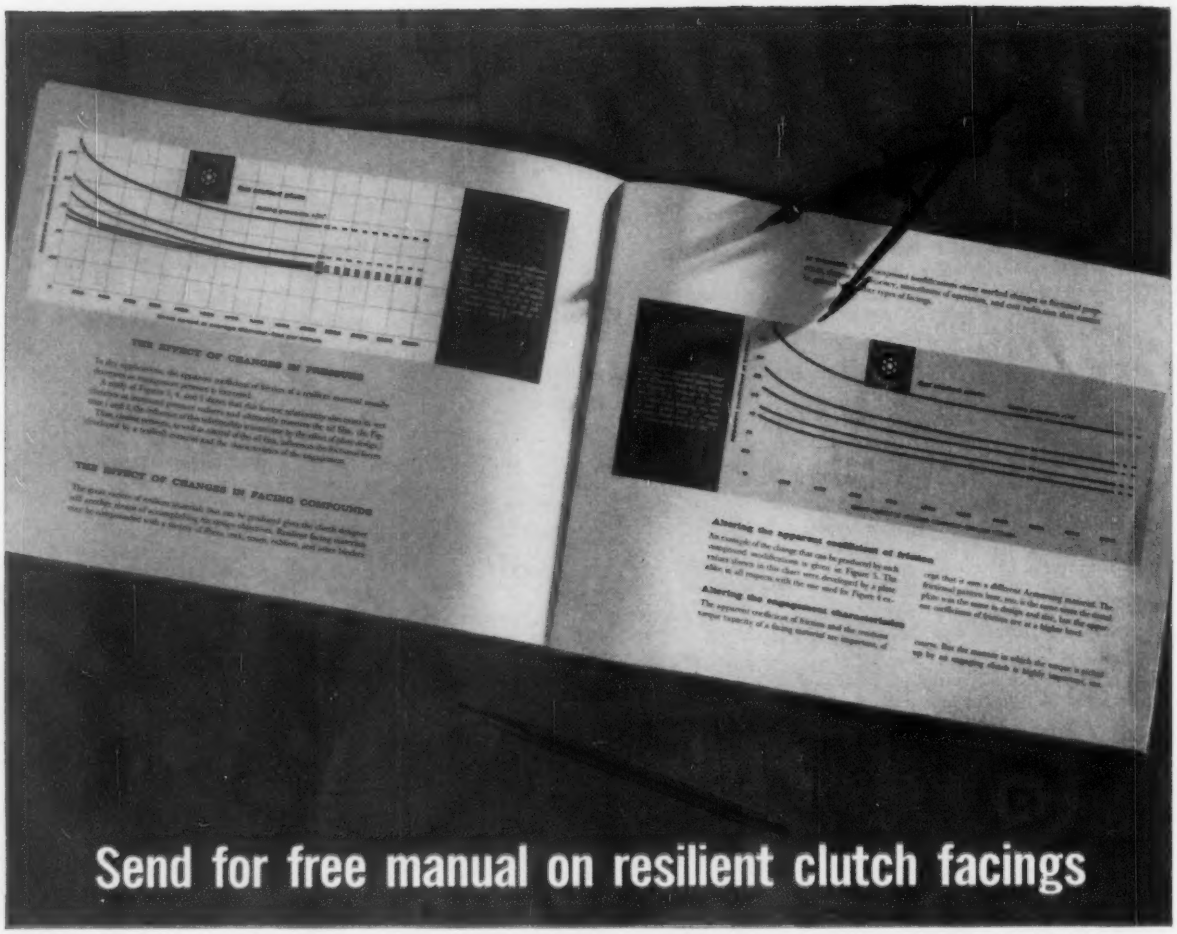
Find us fast in the "Yellow Pages"

NON-ROTATING AIR AND HYDRAULIC CYLINDERS • ROTATING AIR AND HYDRAULIC CYLINDERS • POWER CHUCKS • COLLET AND DRILL PRESS CHUCKS • VALVES, ACCESSORIES

A BASSETT COMPANY • IN GREATER CLEVELAND • ESTABLISHED 1916

AA-7486

Circle 480 on Page 19



Send for free manual on resilient clutch facings

This new 16-page booklet contains data, charts, graphs, and a handy check list—all designed to help you use resilient facings to get the performance you want from your clutch. It gives you information on:

1. How the higher coefficient of friction of resilient facings helps cut production costs. 2. How to control apparent coefficient of friction to get desired clutch performance. 3. How plate design affects engagement characteristics. 4. How resilient facings may make it possible to reduce number of plates, plate diameter, or closing pressure. 5. The wide range of compounds available including new fiber materials for high pressures and temperatures. 6. Technical assistance Armstrong offers you.

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Send today for this free booklet. Just mail the coupon or write for your copy of "Armstrong Resilient Friction Materials." Address Armstrong Cork Company, Industrial Division, 7210 Dean Street, Lancaster, Pennsylvania.

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RESILIENT FRICTION MATERIALS

. . . used wherever performance counts

Circle 481 on Page 19

Air Moving Units

Special purpose air moving units for original equipment manufacturers are described and illustrated in Bulletin 5412. Covered are packaged centrifugal blowers, vaneaxial fans, tubeaxial fans, propeller fans, pressure blowers, and fluid coolers. Various configurations are offered. Specifications of each unit are given, along with application data. 16 pages. American-Standard, American Blower Div., Detroit 32, Mich. H

Circle 627 on Page 19

Epoxy Glass Laminates

Test values and curves, plus specification data on epoxy glass copper-clad and unclad laminates for printed and other circuitry are found in a technical data manual. Bond strength, dielectric breakdown, and other factors are covered. Extensive technical data are presented. 21 pages. Mica Corp., 4031 Elenda St., Culver City, Calif. L

Circle 628 on Page 19

Metallic Welded Bellows

Made from any suitable weldable material, Formweld metallic welded bellows have wide application in various fields. Their characteristic and specifications are presented on an illustrated data sheet. 2 pages. Robertshaw-Fulton Controls Co., Bridgeport Thermostat Div., 155 Hill St., Milford, Conn. B

Circle 629 on Page 19

High Alumina Ceramics

"Coors Space Age Ceramics" is title of Bulletin 858 which outlines production facilities and mechanical and electrical properties of high alumina ceramics. They offer high temperature resistance and strength in electrical and mechanical equipment. 4 pages. Coors Porcelain Co., 600 Ninth St., Golden, Colo. K

Circle 630 on Page 19

Explosive Power Units

Five components which provide explosive power for various functions in missiles and aircraft are described in Form PEP-4-658. These include explosive bolt cartridges, pressure cartridges, gas generators, igniters, and miscellaneous high-explosive components. 4 pages. Holex Inc., San Juan Rd., Hollister, Calif. M

Circle 631 on Page 19

Use of Resistors

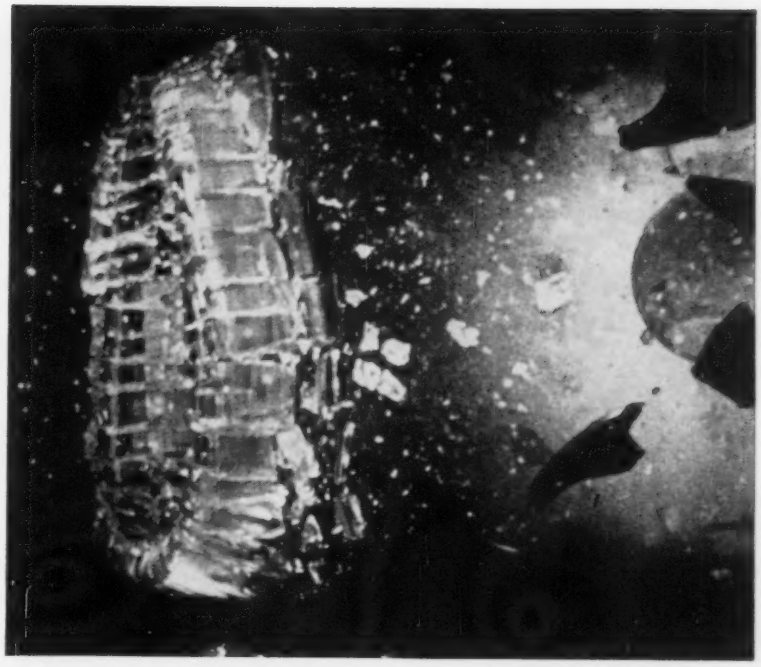
"How Not to Use Resistors" is title of folder written in a humorous vein. Folder is a sequel to a previous successful piece entitled "How Not to Use Transistors." General Transistor Corp., 91-27 138th Place, Jamaica 35, N. Y. D

Circle 632 on Page 19

Transfer Switches & Timers

Pocket-size folder gives supplementary listings of automatic transfer switches, magnetic contactors, program and interval timers, and reversing controls. Text includes capacities, dimensions, ratings, and list prices. 8 pages. Zenith Electric Co., 152 W. Walton St., Chicago 10, Ill. J

Circle 633 on Page 19



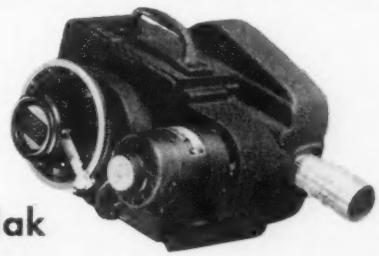
Single frame from a high speed movie of an imploding television picture tube—a critical instant seen in relation to what preceded and followed during a spread-out fraction of a second.

Ever see a really high speed movie?

It's something to see—a one-second swipe of a cutting tool spread out to three minutes on the screen! Seeing a cam that is really turning at 500 RPM (and behaving that way) as though it were turning at 3 RPM! Studying the action of explosions, welding bead deposition, forging . . . all slowed as much as 200 times from normal.

We've put together a movie on the Kodak High Speed Camera that will show you what high speed movies can do. It will also give you some ideas on how you might put high speed movies to work solving your own design, production, and performance problems that involve high speed mechanical action or fluid flow. To arrange for a showing to company groups of the 16mm sound movie, "Magnifying Time," write:

EASTMAN KODAK COMPANY, Rochester 4, N.Y.

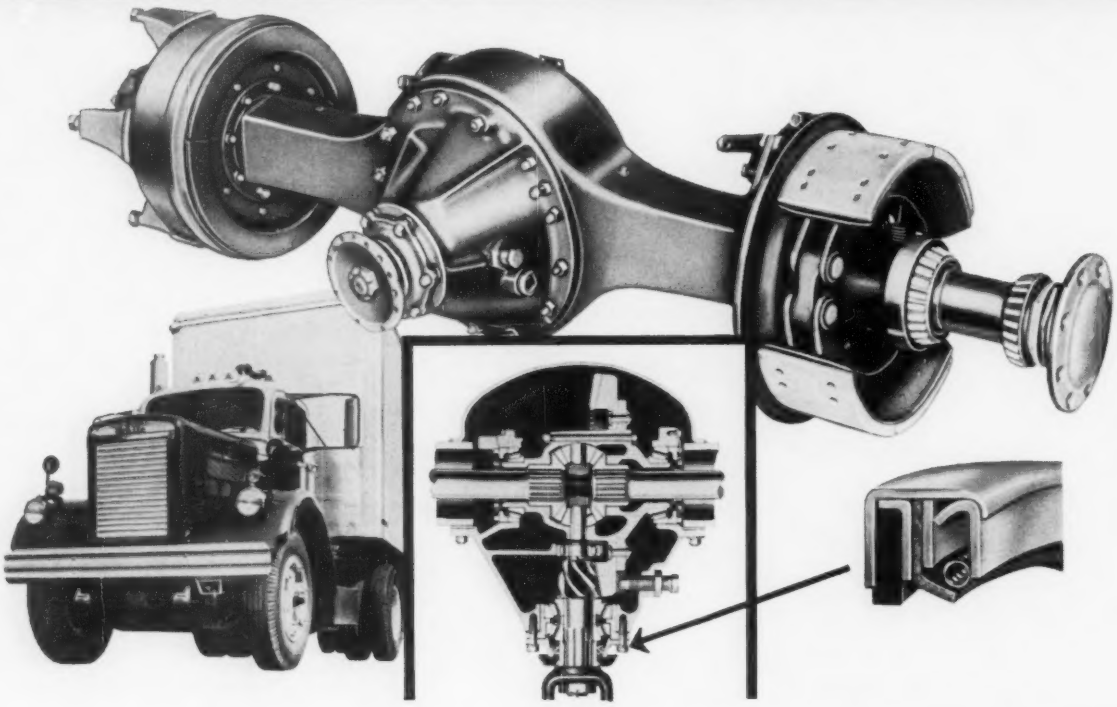


the Kodak HIGH SPEED Camera

Kodak TRADE MARK

Circle 482 on Page 19

NATIONAL OIL SEAL LOGBOOK



How White Trucks employ dual-lip National seal to protect axle pinion assembly

The use by the White Motor Company of a National 15,000 series oil seal in their 189C Single Reduction Rear Axle is a skillful employment of a standard-design seal to attain dependable and economical sealing.

Conditions at the sealing point are: S.A.E. 90 gear oil to be retained, dirt and water to be excluded, temperatures —20° to 180° F with normal operation at 150° F, maximum shaft speed 3,500 rpm, eccentricity and runout .002, shaft diameter 2¾", 15 RMS finish. Operation is of course intermittent with servicing conditions generally good.

Rather than two seals to respectively retain lubricant and exclude foreign matter, White engineers specified National 15004, a dual-lip Micro-Torc leather and felt seal wherein the leather sealing lip is spring-tensioned and faces inward to retain gear oil and the other felt lip is a wiper excluding dirt and dust.

National 15004 is but one of 2,500 different standard design seals National provides. For complete information on leather, synthetic rubber or other seals, call your National Applications Engineer. Look under Oil Seals, in the Yellow Pages.

NATIONAL SEAL

Division, Federal-Mogul-Bower Bearings, Inc.
General Offices: Redwood City, California;
Plants: Van Wert, Ohio, Downey and Redwood City, California

Before specifying seals, consider all these points!

Shaft RPM, Runout, Endplay
Is seal rated at or above anticipated operating extremes?

Temperature, Lubricant Types
Will heat or special-purpose lubricants attack sealing lip material?

Presence of Dirt, Foreign Matter
Point often overlooked. Should dual-lip or double seal be used?

Cost Related to Seal Design
Will a simpler, cheaper seal do as good a job as a more sophisticated design?

New Seals and Material Available
Are there new materials or compounds which can do the job better?

Special Design Oil Seals
Not all problems can be met with stock seals. Is special factory design indicated to meet special problems?

Delivery, Reputation
Is my proposed resource noted for good delivery, uniform quality and good follow-up service?

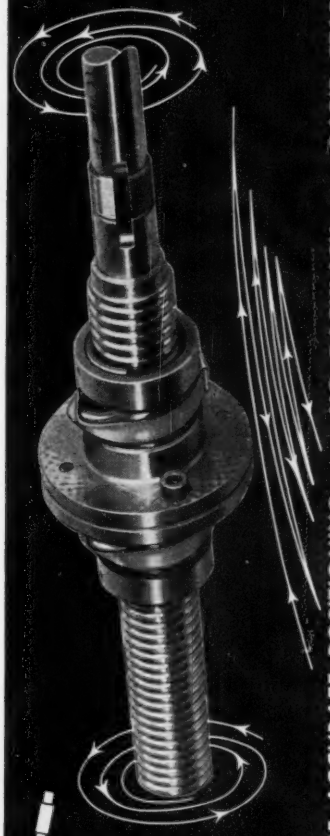
Don't specify "blind." Your National Seal Applications Engineer has up-to-the-minute oil seal information. Ask him—before you specify. Takes only a phone call; no obligation!

4954

BEAVER BALL SCREWS

Successor to the Acme screw drive and preferred in many applications to hydraulic and pneumatic systems. Guaranteed 90% efficient in converting rotary twist to linear push (or vice versa). Employs a stream of precision balls and ground lead to eliminate drag and wear in delicate instruments, aircraft, machine tools, massive wind tunnel jacks, etc. For horizontal and vertical actions, indexing, inching and traversing. Consultation and engineering service available. Write for literature.

• EXTREME ACCURATE POSITIONING • NO BACKLASH • RAPID START • ANY DIAMETER OR TRAVEL •



Beaver Precision Products INC.
CLAWSON, MICH.

Circle 484 on Page 19

Sleeve Bearings & Bushings

Catalog 58, one of two indexed catalogs on sleeve bearings and bushings, lists 866 sizes of cast bronze bearings and well over 600 sintered, oil-filled bearings. Catalog 258 lists specifications of 343 cast bronze electric motor bearings made for motors ranging from 1/50 to 100 hp. Bunting Brass & Bronze Co., Toledo, Ohio. G

Circle 634 on Page 19

Hoists & Cranes

End trucks, Gard-Elex enclosed conductors, Load Tamer hoists, crane drives and fluid drive motors, trolleys, runway rails, hanger fittings, and other components for building top riding and underslung cranes from 1 to 15 tons capacity are described in Catalog 58 A. Consolidated Crane & Engineering Corp., 767 N. Georgia St., Azusa, Calif. L

Circle 635 on Page 19

High Strength Aluminum

Properties and aging practices relative to high strength aluminum alloy X357 are discussed in brochure reprint of a report presented at the American Foundrymen's Society Foundry Show. Report is by A. B. DeRoss, technical specialist, Pig and Ingot Product Office. 8 pages. Kaiser Aluminum & Chemical Sales, Inc., 919 N. Michigan Ave., Chicago 11, Ill. I

Circle 636 on Page 19

High Vacuum Valves

Quick-acting air cylinder and a full opening design are features of Series 217 right angle poppet type high vacuum valves described in Data Sheet 570. Available sizes are 4, 6, 10, and 16 in. F. J. Stokes Corp., Vacuum Equipment Div., 5500 Tabor Rd., Philadelphia 20, Pa. E

Circle 637 on Page 19

Magnetic Amplifier

The 430 integrating magnetic amplifier is used in missile guidance systems, industrial controls, and other precision controls. Data Sheet 1057 describes this 115-v, 400 cps unit which weighs less than 9 oz. Acromag, Inc., 22519 Telegraph Rd., Detroit 41, Mich. H

Circle 638 on Page 19

Motor Starting Relays

Rating and dimensional data are provided on 9660 Series motor starting relays in Bulletin STRE-3. Relays are used on single-phase, ac hermetic, and refrigeration motors. 4 pages. Metals & Controls Corp., Spencer Div., Attleboro, Mass. B

Circle 639 on Page 19

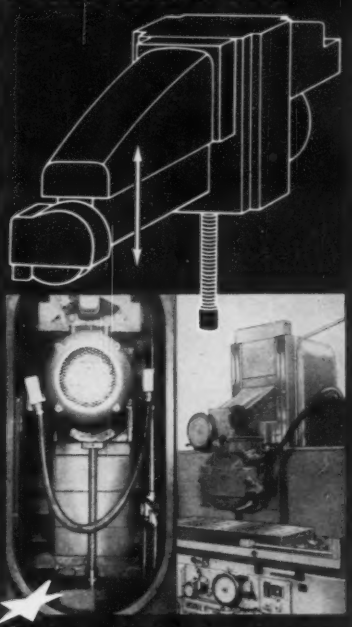
Rotary Gas Pumps

Revised Bulletin XA-458 presents technical rating data along with design and construction information on XA rotary positive gas pumps. These units are available in 18 sizes. 6 pages. Dresser Industries, Inc., Roots-Connersville Blower Div., 900 W. Mount St., Connersville, Ind. J

Circle 640 on Page 19

OPA ★

Gallmeyer & Livingston got it when they changed to a Beaver Ball Screw!



Optimum Positioning Accuracy with system stiffness in the head slide of their Model F surface grinder was the design objective of Gallmeyer & Livingston engineers when they changed from an acme to a ball screw — The other advantages they gained were bonuses!

Does your product require precise control of very small increments of motion? Make use of our extensive engineering and application experience. Write for free catalog.

Beaver Precision Products INC.
CLAWSON, MICH.

Circle 484 on Page 19

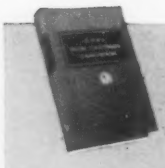
DESIGN HISTORY IS BEING MADE

by modern gray & ductile iron castings!

Block link for chain redesigned to a ductile iron casting eliminated 20 operations, and saved $42,000 in equipment.
The Jeffrey Manufacturing Co.
Changing this compressor discharge casing to a high strength gray iron casting saved 58% in material and 34% in machining costs.
General Electric Company
A cost reduction of up to $20 a set was made by using ductile iron to make these wing-form bodymakers.
National Can Corporation
This oil pump spacer when converted to cast iron eliminated carburizing and finishing operations and saved 88%.
Detroit Diesel Engine Division, GMC.

Four Winners 1957 GIFS Contest

Almost every day design history is being made by gray and ductile iron castings! Modern metallurgy is providing gray irons with new highs in properties . . . new molding techniques are producing castings with better surface finish and closer dimensional accuracy. Such outstanding developments are causing engineers to consider gray and ductile iron *first* in designing products. Write for the GRAY IRON CASTINGS HANDBOOK. Save money by learning more about this remarkable material.



NEW 620 Page Handbook

Just off the press. Cost-cutting design and purchasing information on new ductile, regular and special iron castings. 400 illustrations, 64 tables, 263 subjects. Mail coupon for TEN DAYS FREE EXAMINATION. At the end of 10 days remit $10 or return the book.

GRAY IRON FOUNDERS' SOCIETY INC.
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☐ $10 enclosed ☐ bill after 10 days
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*Company*_____
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*City*_____ *Zone*____ *State*_____

TIME TO DESIGN WITH **GRAY IRON CASTINGS**

Circle 486 on Page 19

HELPFUL LITERATURE

Pressure-Vacuum Controls

Many specifications and pertinent descriptive data are provided in condensed Catalog 500 on a variety of pressure-vacuum controls. Covered are general purpose, sensitive, dual switch differential, absolute, and explosion-proof units. Catalog is classified for rapid reference. 8 pages. United Electric Controls Co., 79 School St., Watertown, Mass. B

Circle 641 on Page 19

Lighted Pushbutton Switches

Data Sheet 143 on 100PB Series building-block light pushbutton switches stresses the new pushbutton design concept which enhances panel-front styling. Types of switches available, their assembly to the panel, and their dual lamp illumination are described. 8 pages. Minneapolis-Honeywell Regulator Co., Micro Switch Div., Freeport, Ill. K

Circle 642 on Page 19

Miniature Power Connectors

Series 250 miniature rectangular power connectors, described in folder as to their outline and mounting dimensions, electrical and mechanical ratings, and enclosures, are available in 20, 34, 50, and 75-contact models. They have solderless taper-pin wiring. 6 pages. DeJur-Amsco Corp., 45-01 Northern Blvd., Long Island City 1, N. Y. D

Circle 643 on Page 19

Metal Film Resistors

Increased resistance range is offered in line of metal film precision resistors which has been reduced in size. Bulletin 155 also describes new shapes and lower temperature coefficient of resistance now established as standard for these units. Ohmite Mfg. Co., 3696 Howard St., Skokie, Ill. J

Circle 644 on Page 19

Swivel Casters

A gyro-action bearing is used to replace conventional king pin in Series 3100 swivel casters described in Bulletin DP 1000-8. Specs show details of six types with load capacities up to 500 lb. 6 pages. Rapids-Standard Co., 342 Rapistan Bldg., Grand Rapids 2, Mich. H

Circle 645 on Page 19

Flexible Coupling

Available for up to ½-in. diameter shafts, the Naugler flexible coupling described in illustrated bulletin compensates for angular and lateral misalignment. It has zero backlash and is dynamically balanced. 4 pages. Naugler Engineering, 19 Madison Ave., Beverly, Mass. B

Circle 646 on Page 19

FHP Motors

Complete design and performance data on Type N alternating and direct current motors, with standard ratings from 1/150 to 1/6 hp at 1725 rpm, are presented in Bulletin 1021, Section 2005. 8 pages. Bodine Electric Co., 2500 W. Bradley Pl., Chicago 18, Ill. J

Circle 647 on Page 19

GARLOCK Package Mechanical Seal Eliminates Leakage, Prevents Shaft Wear

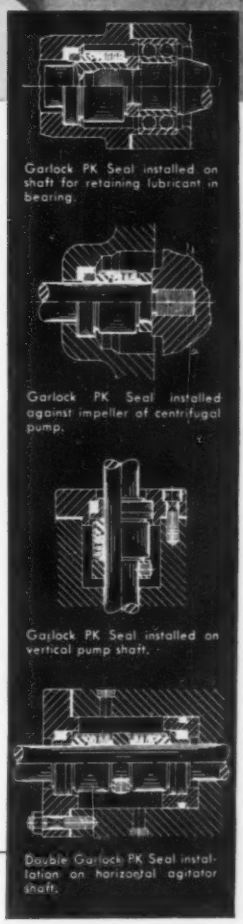
Completely self-contained, the Garlock PK seal is simple to install and offers long, care-free service against water, oils, alcohol, mild acids, and solvents . . . against temperatures to 212° F., pressures to 150 psi, and shaft speeds to 2000 fpm.

ELIMINATE LEAKAGE. On Garlock's PK MECHANIPAK,* the sealing faces of the rotating and stationary parts are precision lapped for perfect contact, thus assuring leak-proof sealing.

ELIMINATE SHAFT WEAR. There are no parts of the Garlock PK MECHANIPAK seal that move on the shaft or the sleeve, thus removing the danger of scoring and wear.

CUT DOWNTIME, MAINTENANCE. Once the Garlock PK MECHANIPAK seal is applied, no further adjustments are necessary. Life is equal to many sets of conventional packing.

USED ON A HUNDRED AND ONE JOBS. Pumps, speed reducers, automatic washers, commercial dishwashers, disposal units, and construction equipment are just a few examples of where you can apply Garlock MECHANIPAK seals. They're another part of the Garlock 2,000 . . . two thousand different styles of packings, gaskets, and seals for every need. The only complete line. That's why you get unbiased recommendations from your Garlock representative. Call him today or write for MECHANIPAK Catalog AD-150.



Garlock PK Seal installed on shaft for retaining lubricant in bearing.

Garlock PK Seal installed against impeller of centrifugal pump.

Garlock PK Seal installed on vertical pump shaft.

Double Garlock PK Seal installation on horizontal agitator shaft.

THE GARLOCK PACKING COMPANY, Palmyra, N. Y.

For Prompt Service, contact one of our 30 sales offices and warehouses throughout the U. S. and Canada.

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Packings, Gaskets, Oil Seals, Mechanical Seals, Molded and Extruded Rubber, Plastic Products

Circle 487 on Page 19

They're Here!

NEW ADDITIONS TO THE

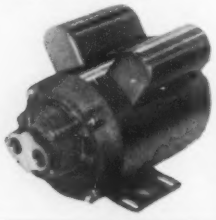
ROPER T SERIES

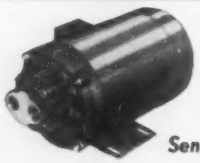
COMPACT, INTEGRAL PUMP AND MOTOR UNITS
For Hydraulic, Pressure Feed, Transfer Work

.3 to 55 GPM
Pressures to 400 PSI

NOW...A CHOICE OF 192 MODELS

Roper has expanded its line of Series T rotary pump units to take care of a wider range of uses pumping clean liquids. These "all-in-one" units, with pump serving as the end bell of the motor, are easily installed and have minimum space requirements . . . no coupling is required . . . each unit is approximately same size as standard NEMA motor of HP required for driving. For your specific application consult the Roper representative in your vicinity.





- **COMPLETE, COMPACT UNITS**
- **LOW FIRST COST**
- **MOUNT IN ANY POSITION**
- **LONG LIFE SERVICE**
- **LIGHT WEIGHT**

Roper Series T units are available in short, low and larger units with open drip proof or totally enclosed motors, single or three phase as required. Typical applications include: hydraulic door openers, work table movement, hospital beds, dental chairs, general transfer, as well as metering jobs on a wide variety of applications.

Send for Bulletin 31

ROPER HYDRAULICS, INC.
250 Blackhawk Park Avenue
Rockford, Illinois

ROPER
ROTARY PUMPS

HELPFUL LITERATURE

Graph & Chart Tapes

Over 435 pressure-sensitive tapes of many sizes, colors, and patterns for making graphs, charts, layouts, printed circuit drawings, map overlays and slides are illustrated in booklet "Visualization Made Easier." Directions are given for making office and plant layouts and organization and flow charts. Tapes as narrow as 1/64 in. are listed. 32 pages. Chart-Pak, Inc., Leeds, Mass. B

Circle 648 on Page 19

Electrical Insulation

Details of the Silco-Flex impervious insulation system for motor and generator stator cores are given in Bulletin 05B8341A. Properties attributed to this insulation are resistance to aging, abrasion, chemicals, corona, fire, moisture, solvents, fungus, carbon black, and arcing. 6 pages. Allis-Chalmers Mfg. Co., Milwaukee 1, Wis. K

Circle 649 on Page 19

Automatic Controls

"Automatic Controls for Heating, Air Conditioning, and Refrigeration" is title of bulletin on a comprehensive line of thermostatic temperature, pressure, flow, and other controls as well as such supplementary equipment as relays, transformers, pilots, and valves. Full specifications of each are given in Catalog R-1558. 48 pages. White-Rodgers Co., 1209 Cass Ave., St. Louis 6, Mo. I

Circle 650 on Page 19

Right-Angle Gear Drives

Solutions to a wide variety of industrial power transmission problems by using standard 90-degree gear drives are shown in Catalog LA-58. Tables, graphs, and drawings explain applications and performance of these ANGLgear units. Ratings from 1/3 to 5 hp are available in 16 models with 1:1 or 2:1 shaft ratios. 4 pages. Airborne Accessories Corp., 1414 Chestnut Ave., Hillside 5, N. J. D

Circle 651 on Page 19

Variable Speed Drive

Offering direct current variable speed drive from an alternating current network, the Automator is a three-element unit which provides virtually stepless control by means of single knob rheostat. Sizes range from 5 to 150 hp. Perpormance data and design details are given in Bulletin SB-183. 4 pages. Marathon Electric Mfg. Co., Wausau, Wis. K

Circle 652 on Page 19

Thermometer

Usable for measuring the temperature of gas, liquid, or solids, the Dual Range Therm-O-Meter has a switch to select either a − 50 to 100° F or a 100 to 250 ° F range. Features include a self-shielded core magnet meter movement, a 15-ft thermistor lead, and a large 7-in. scale for accuracy and easy reading. Details are given in Form 4001. 2 pages. Simpson Electric Co., 5200 W. Kinzie St., Chicago 44, Ill. I

Circle 653 on Page 19

High Temperature Material

Designed to operate in temperatures ranging to 3000° F, Haynes silicon nitride is available in a wide range of shapes and sizes. Parts are made by slip casting and can be machined. Full details are given in Bulletin F-30114. 8 pages. Haynes Stellite Co., Kokomo, Ind. C

Circle 654 on Page 19

Explosive Valves & Latch Pins

Standard and special types of explosive-actuated valves, latch pins, and actuators as well as thermocouple and pressure sealing assemblies are covered in Catalog 5808-XV. Most of the explosive devices meet or exceed applicable military specifications. 16 pages. Conax Corp., 2300 Walden Ave., Buffalo 25, N. Y. N

Circle 655 on Page 19

Stainless Welding & Brazing

Welding, brazing, soldering, and hot cutting of Enduro stainless steels are comprehensively treated in Brochure 585R2. Welding methods are classified as fusion, resistance, pressure, and forge welding and include gas and arc welding, inert gas and submerged arc welding, spot and seam welding, and butt welding techniques. Procedures are discussed. 54 pages. Republic Steel Corp., Cleveland 1, Ohio. F

Circle 656 on Page 19

Check Valves

Used in hydraulic and pneumatic circuits, Pressure Cushioned Kep-O-Seals are check valves for service at pressures to 3000 psi hydraulic, and they operate in the — 40 to 280° F range. Full details are given in illustrated bulletin. 4 pages. Kepner Products Co., 7321 W. 59th St., Summit, Ill. J

Circle 657 on Page 19

Pressure Transducers

Bulletin PSG-1 is technical presentation on gage, absolute, and differential pressure measurements. Circuit diagrams, complete specifications, and operating details of pressure transducers are included. 4 pages. Gulton Industries, Inc., 212 Durham Ave., Metuchen, N. J. D

Circle 658 on Page 19

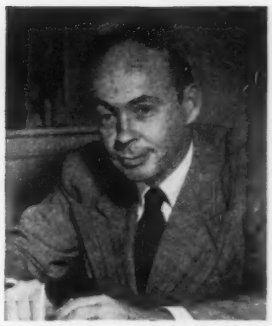
Engineering Facilities

Facilities for engineering, consulting, drafting, prototype fabrication, and testing offered by this firm are detailed in an illustrated brochure. Biographies of key personnel are presented. 20 pages. Request on company letterhead from Horkey-Moore Associates, 24660 S. Crenshaw Blvd., Torrance, Calif. L

Electronic Hardware

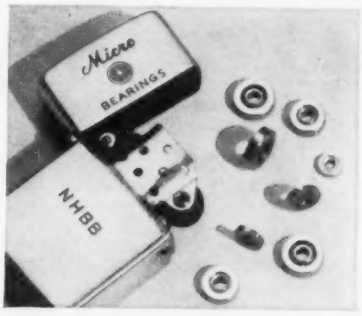
Pictures, diagrams, dimensions, and lists of over 100 different types of standard electronic hardware are found in reference manual. Included are banana plugs and jacks, binding posts, chassis fasteners, contact strips, handles, pilot lights, standoffs, terminal strips, and many others. 75 pages. Request on company letterhead from Amatom Electronic Hardware Co., 88 Drake Ave., New Rochelle, N. Y. D

MICRO-BEARING ABSTRACTS



by **A. N. DANIELS**, *President*
New Hampshire Ball Bearings

NEW "MICROWAFER" BEARINGS FEATURE NARROWER WIDTHS



There's a new, lean look in miniature ball bearings these days. It was brought about by the demands of designers of small synchros, servos, motors, potentiometers and gear trains. They said that standard shielded miniature bearings were much too "fat". They asked for "skinny" bearings that would allow them to increase the width, strength or capacity of working components.

Back in 1955, New Hampshire Ball Bearings, Inc., introduced its UP line (U for thin, P for single shield). These bearings satisfied a good many designers. These special shielded bearings have the same width as standard unshielded bearings of the same O.D. and bore. But some designers still insisted on thinner bearings.

In 1958, they got what they asked for. A new series of thin bearings, called "Microwafers" was introduced. These light bearings offer the advantages of widths as much as 40% narrower than standard unshielded bearings of the same O.D. and bore, as illustrated in *Fig. 2.*

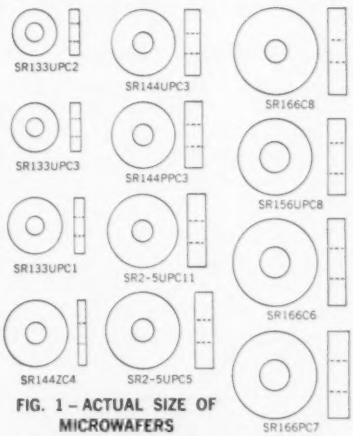


FIG. 1 – ACTUAL SIZE OF MICROWAFERS

The space-saving feature of these new "Microwafer" bearings has been welcomed particularly by designers of small servos, synchros and motors. It permits miniaturization to be carried a step farther when smaller packages are required. In other cases, the narrower bearing widths allow the addition of more iron or copper to rotors and stators without changing package size. This means that greater capacity and improved performance can be built into existing designs.

TWELVE NEW NUMBERS

"Microwafer" bearings are now available in twelve numbers: seven with single shields, one with two shields and four unshielded, as charted below.

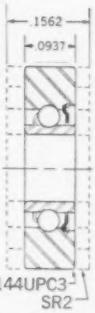
NUMBER	BORE	O.D.	WIDTH
SR133UPC2	.0937	.2500	.0625
SR133UPC3	.0937	.2750	.0625
SR133UPC1	.0937	.3125	.0625
SR144ZC4*	.1250	.3750	.047
SR144UPC3	.1250	.3750	.0937
SR144PPC3**	.1250	.3750	.1094
SR2-5UPC11	.1250	.4250	.1094
SR2-5UPC5	.1250	.4375	.1094
SR166C8	.1250	.5000	.1094
SR156UPC8	.1875	.4375	.1094
SR166C6	.1875	.5000	.1094
SR166PC7	.1875	.5000	.1250

*Unshielded, spring separators
**Two shields

SPECIFICATIONS

Starting Torque: Standard starting torque is 1400 mg mm under 75 gm thrust, 90% guaranteed at 1100 mg mm if specified. Lower levels by selection.
Material: 440 C stainless steel.
Tolerances: ABEC7 or better.
Radial Play and Lubrication: as specified by customer.

Complete specifications are contained in one design handbook.



COMPARISON OF MICROWAFER SR144UPC3 WITH STANDARD MICROBEARING SR2

FIG. 2

DESIGNERS HANDBOOK FREE TO ENGINEERS

If you work with miniature ball bearings, you'll find this 80-page authoritative handbook a great help in solving problems in designing instruments or electro-mechanical assemblies. It will be sent free to qualified engineers, draftsmen and purchasing agents. Write:

NEW HAMPSHIRE BALL BEARINGS, INC., PETERBOROUGH 1, NEW HAMPSHIRE

Circle 489 on Page 19

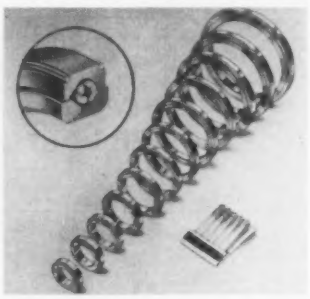
New Parts and Materials

Use Yellow Card, page 19, to obtain more information

Ball Bearings

have integral-shield design

Type TWF instrument ball bearings are of thin-section design, and are available in twelve sizes with bores from $\frac{5}{8}$ to $3\frac{1}{16}$ in. Integral shields are formed by extending lands of inner and outer rings to within a few thousandths of an inch of each other. Resulting close-clearance annulus fills with lubricant to function as an effective seal without friction of contact seals. Ball races are of deep-groove type with continuous shoulders. No filling slots are employed, allowing full utilization of potential thrust capacity of bearing. Full ball complements are used, permitting maximum radial and two-directional thrust capacity. Bearing is suitable for applications where high static capacity is required, or where there is oscillating movement. **Split Ballbearing Div., Miniature Precision Bearings Inc.**, Lebanon, N. H. B

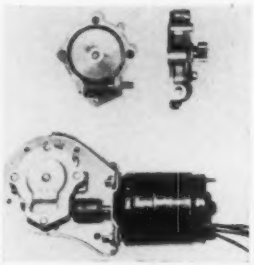


Circle 659 on Page 19

Gear-Reduction Unit

has transmission ratio of 52:1 or 27.5:1

New self-locking worm-gear power transmitter that reduces motor revolutions and increases torque is designed for use in rack and pinion, gear and pinion, or friction-drive operations. Available for operation by fractional-horsepower motors up to 1/9 hp at 2000 rpm, 1/6 hp at 3000 rpm, or 1/5 hp at 4000 rpm, unit can be used for any operation in which electrical power must be converted to rotary or straight-line mechanical actuation. Transmission ratios of 52:1 or 27.5:1 are available, with either six or eight-tooth pinion. Input shaft is $\frac{1}{4}$ in. in diam and 3/16 in. across flats. Output is at right angles to motor shaft input. Designed to operate with both reversible and one-way motors, unit locks against reversing torques on output shaft. **Huppower Div., Hupp Corp.**, 7450 Melville Ave., Detroit 17, Mich. H

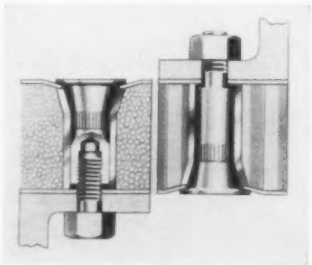


Circle 660 on Page 19

Sandwich-Panel Fastener

has high column strength

Structural-type fastener, consisting of preassembled body and expanding sleeve, provides additional strength for a variety of sandwich-type panels in use in aircraft, missiles, electronics, and other industries. Body section is available in many forms, including internal threaded, threaded stud, male rivet, and through-bolt types. Flush applications with minimum dimple are assured on both skins through die action of body and sleeve. Unit is retained in panel by a splined interlock which also prevents rotation. High column strength of fastener prevents crushing of panels, and maximum shear strength is guaranteed by distribution of loads to both skins. High tension pull-out values are insured by positive skin-gripping feature. Fastener required no filler to hold in panel, resulting in lightweight installation. It is available in a variety of styles, sizes, and materials including aluminum, carbon, and stainless steels. **Delron Co. Inc.**, 5224 Southern Ave., South Gate, Calif. L

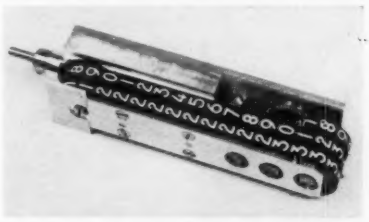


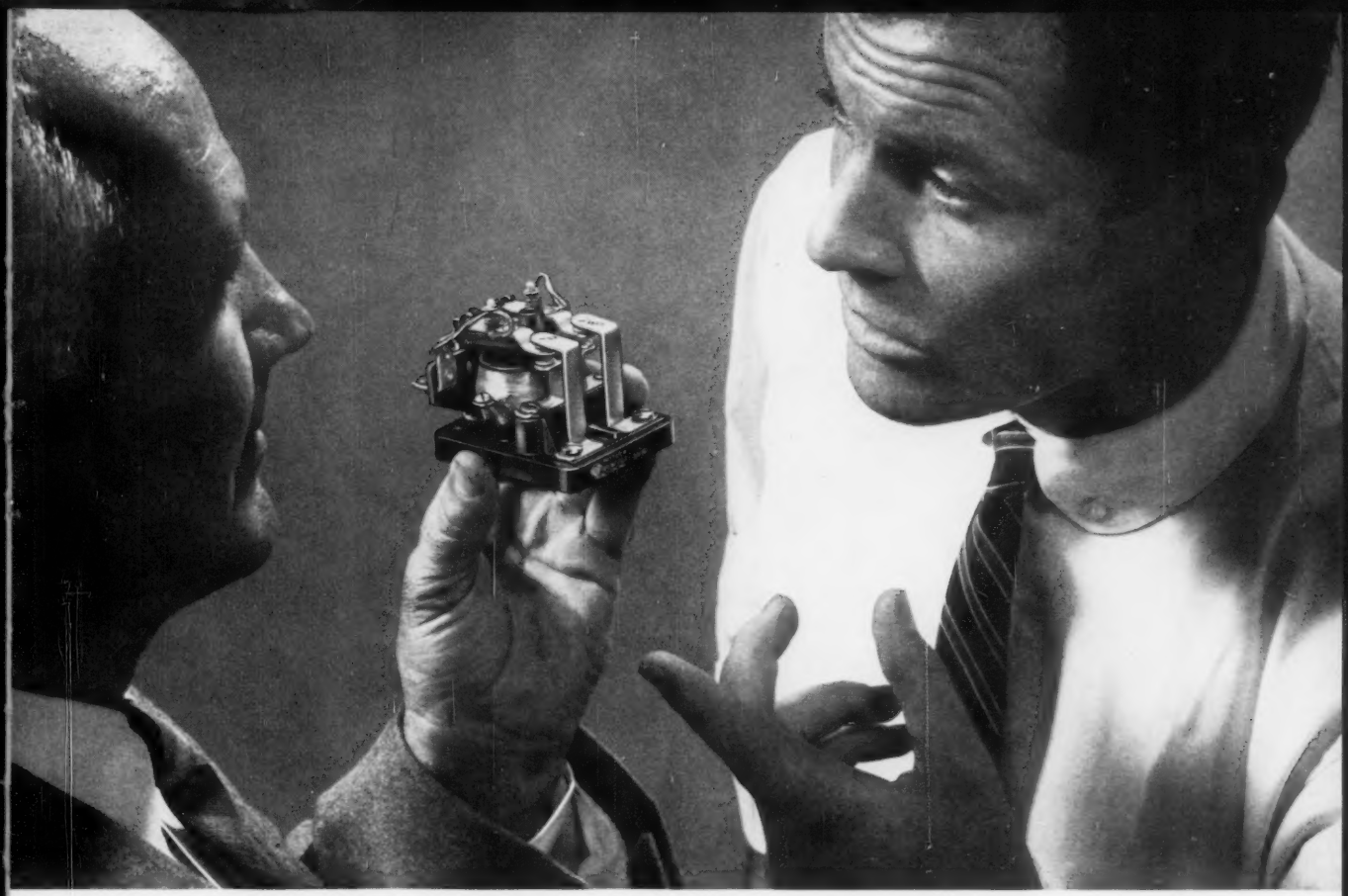
Circle 661 on Page 19

Miniature Angle Counter

has breakaway torque peaks under 0.1 oz-in.

Model 1402-A Minac miniature angle counter is a compact unit which has breakaway torque peaks under 0.1 oz-in. Standard three-digit model counts 360 deg and is available with right-hand, left-hand side, or end input. One revolution of input shaft counts 10 deg. Backlash is negligible, and high-speed running is smooth at speeds to 500 counts per sec intermittent and 250 counts continuous operation. Ambient-temperature operating range is −55 to 125 C. Basic counter design can be adapted to both three and four-digit models, to cycle on other total counts, and to register finer divi-





HERE'S WHY P&B's PR POWER RELAY IS PREFERRED

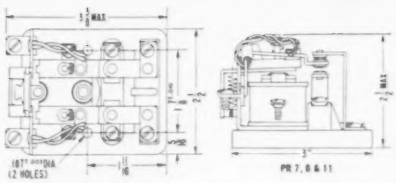
for high current/voltage switching

HEAVY DUTY construction means long-term dependability when switching up to 20 amperes (double break contacts). Here is a ruggedly built relay, packed with high quality features, yet economically priced.

The PR's full floating movable contact carrier, for example, provides excellent contact pressure and ample wipe for self-cleaning contact action. The coil is centrifugally impregnated with top-grade varnish to eliminate moisture traps.

Contact arrangements up to DPDT are available. The PR has been adapted for printed circuitry and heavy duty plug-in applications.

All standard AC actuated PR relays may carry the UL and Canadian Standards Association seals of approval. Write or call for complete information.



GENERAL SPECIFICATIONS:
Breakdown Voltage: 1500 volts rms min. between all elements and ground.
Ambient Temperature: DC: —55° to +85°C.
AC: —55° to +55°C.
Terminals: Heavy duty screw type. Standard printed circuit pins or plug-in on request.
Enclosures: PR dust cover.

CONTACTS:
Arrangements: Up to 2 Form C (DPDT).
Material: 5/16" dia. silver or silver cadmium oxide. (Others available)
Load: Single break: 15 amps; Double break: 20 amps at 115 volts 60 cycle AC resistive.

AUXILIARY CONTACTS:
Arrangements: 1 Form A, B or C.
Material: 3/16" diameter silver
Rating: 5 amps at 115 volts 60 cycle AC resistive.

COILS:
Resistance: 64,000 ohms maximum.
Power: 1.8 watts DC; 9.8 volt-amps AC.
Duty: Continuous AC or DC (DC coils will withstand 10 watts at 25°C).
Insulation: Centrifugally impregnated with high quality varnish.
Mountings: 2 holes .187" diameter 1⅞" o.c.

PR Relays Approved By Underwriters' Laboratories and Canadian Standards Association

Type	Contact Arrangement*	Type	Contact Arrangement*
PR1AY	SPST-NO	PR5AY	SPDT
PR2AY	SPST-NC	PR7AY	DPST-NO
PR3AY	SPDT-NO-DM	PR8AY	DPST-NC
PR4AY	SPDT-NC-DB	PR11AY	DPDT

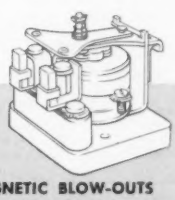
These relays are available in any of the following operating voltages: 6, 12, 24, 48, 115, 208, 230, or 440 volts 50/60 cycles AC.

The contacts are rated at: 13 amps, 115 volts AC. 6.5 amps, 230 volts AC. 1 hp for 115 or 230 volt AC motors.

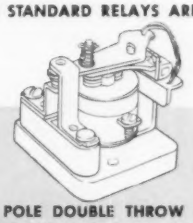
Any relays deviating electrically or physically from these standard models will not carry U/L or CSA approval.

*Read: NO normally open, NC normally closed, DB double break, DM double make.

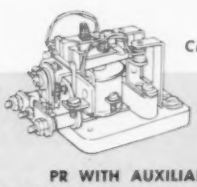
P&B STANDARD RELAYS ARE AVAILABLE AT YOUR LOCAL ELECTRONIC PARTS DISTRIBUTOR



PR RELAY WITH MAGNETIC BLOW-OUTS
Models PR3 and PR7 can be supplied with alnico magnets to suppress arcs on DC loads over 1200 watts.



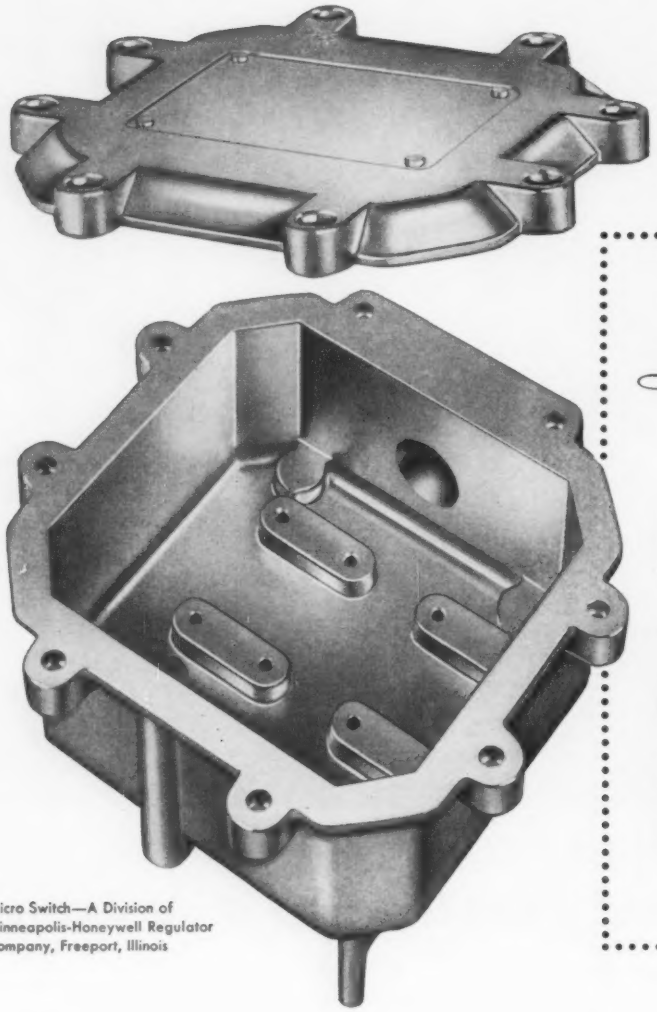
SINGLE POLE DOUBLE THROW VERSION
PR 5 (SPDT) has all the heavy-duty features of other models in this series.



PR WITH AUXILIARY CONTACTS
All PR models can be equipped with auxilliary contacts in 1 Form A, B, or C arrangements.

Circle 490 on Page 19

POTTER & BRUMFIELD INC.
PRINCETON, INDIANA • SUBSIDIARY OF AMERICAN MACHINE & FOUNDRY COMPANY



*Micro Switch—A Division of Minneapolis-Honeywell Regulator Company, Freeport, Illinois

Lifetime Quality

with MADISON-KIPP zinc and aluminum die castings

The earmarks of lifetime quality are never elusive. They are there to see in dis-assembled, unpainted components. They are there to see in break-down tests.

The Kipp die cast body and cover of the *Micro Switch instrument here illustrated are of lifetime quality not only to encase and protect functional parts, but also to provide a rigid frame, ample bearing bosses, stable dimensions, and other last word engineering features.

The attentive mechanics at Madison-Kipp invite you to clip this ad as a reminder to contact them for close cooperation on the momentous details of design when you next have die casting requirements.

kipp

MADISON-KIPP CORPORATION
210 Waubesa Street • Madison 10, Wis., U.S.A.

RESEARCH PARTICIPANT

Skilled in Die Casting Mechanics • Experienced in Lubrication Engineering • Originators of Really High Speed Air Tools

Circle 491 on Page 19

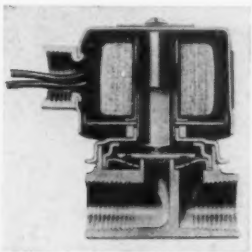
sions. It can be adapted to count 6400 angular mills and conventional counts to 9999. Unit requires panel-mounting area 27/32 in. high x 59/64 in. wide x 4⅛ in. deep. **Mast Development Co. Inc.**, 2212 E. 12th St., Davenport, Iowa. I

Circle 662 on Page 19

Solenoid Valves

have only two moving parts

Two new valves of 5/16 and 3/4-in. port diam have been added to a line of Series J solenoid valves for industrial uses. Valves are used for



flow control of water, air, low-pressure steam, light oils, brines, industrial and LP gases, and other non-corrosive fluids. They have pilot operation, have only two moving parts, and can be mounted in any position. **Controls Div., Jackes-Evans Mfg. Co.**, 4427 Geraldine Ave., St. Louis 15, Mo. I

Circle 663 on Page 19

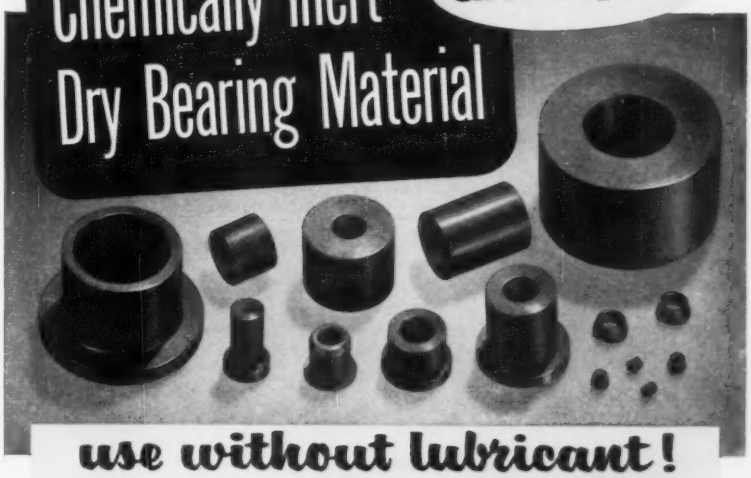
Motors

fractional-horsepower units have plug-in connects

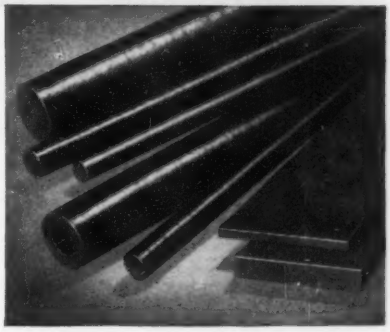
Redesigned Form G fractional-horsepower motors permit reduction of assembly and maintenance costs in a wide variety of applications. New features include plug-in quick-connects for all terminals, quick change of rotation by reversal of two plug-in motor leads, and brass links that simplify voltage change on dual-voltage motors. Enlarged wiring compartment and narrower terminal board permit fast hook-ups during installation. Other changes include antirust-treated shaft and bright-plated hardware for protection against corrosion, built-in lug for grounding connection, and composition washer in centrifugal switch for quiet operation. New bonding method is used for insulating stator

Chemically Inert Dry Bearing Material

Chemloy 719



use without lubricant!



Chemloy 719 is proving to be the most *universal* dry bearing material ever offered to industry:

. . . because its extremely low coefficient of friction invites use where lubrication is impossible, impractical or undesirable.

. . . because it may be used on both sliding and rotating applications over a wide temperature range.

. . . because it is impervious to practically all known chemicals, solvents or corrosives.

. . . because it is excellent under vibration or shock service conditions.

. . . because it will not conduct electricity or cause galvanic corrosion.

Chemloy 719 is available in all basic forms—such as sheet, rod or tubing—or in parts molded or machined to specifications. Get full details.

Request Bulletin T-120 and Price Sheet No. 126, or send b/p or specs. for quotation on molded or machined parts.

CRANE PACKING COMPANY

6425 OAKTON ST., MORTON GROVE, ILL. *(Chicago Suburb)*

In Canada: Crane Packing Co., Ltd., Hamilton, Ont.

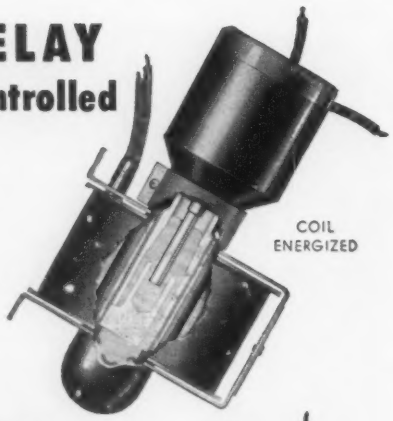
John Crane

CRANE PACKING COMPANY

Circle 492 on Page 19

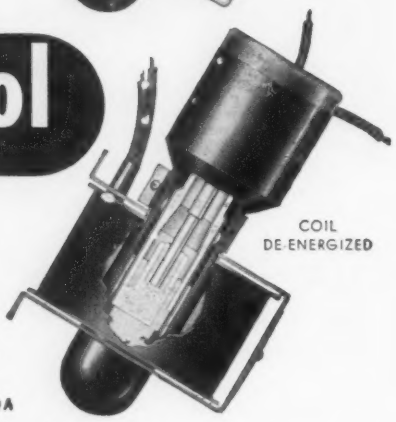
The **TIMER RELAY**
that handles all controlled timing problems . . .

This steel clad, factory set, tamper proof Durakool timer-relay is practically non-breakable. Operating life multiplied 5 to 6 times by new plunger construction features. Combinations of operate-release time delays from 0.15 sec. to 20 sec.—either normally open or normally closed action.



Durakool
STEEL MERCURY TIMERS

- ★ No false contacts
- ★ Non sticking
- ★ Practically "fail safe"
- ★ Low cost timer



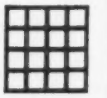
See telephone directory for local distributor, or write.
DURAKOOL, INC.
ELKHART, INDIANA, U. S. A.
700 WESTON RD., TORONTO 9, CANADA

Circle 493 on Page 19

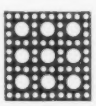
Idea!
. . . aesthetic functionalism . . . with H & K perforated metals

The perception of the Industrial Designer and other men of ideas, in the selection and adaptation of aesthetically interesting and functionally honest mediums, is constantly proving the versatility of H & K Perforated Metals.

For more than 75 years, Harrington & King has helped to broaden the horizons of industrial design through the creation of unlimited patterns in both metallic and non-metallic materials. If perforated materials can be utilized in your product, our sales engineers will be pleased to work with you.



Write for catalog today! It shows thousands of patterns.



A few of the thousands of H & K patterns are illustrated in reduced size

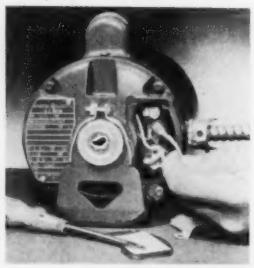
*Product Development by William M. Schmidt Associates.

THE Harrington & King PERFORATING CO. INC.

Chicago Office and Warehouse
5670 Fillmore Street
Chicago 44, Illinois

New York Office and Warehouse
114 Liberty Street, Dept. MD
New York, New York

Circle 494 on Page 19



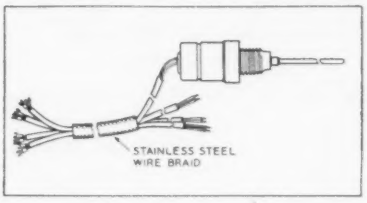
winding, and metal clamps securely fasten stator laminations for more uniform core alignment. New features are available, when appropriate, on split-phase, capacitor-start, permanent-split capacitor, and polyphase Form G motor types. **General Electric Co.**, Schenectady 5, N. Y. C

Circle 664 on Page 19

Bendable Thermocouple

measures temperatures to 2000 F

Armorox metal-sheathed, ceramic-insulated thermocouple is easily bent around twice its own diameter to get into hard-to-reach places. Sheathing is available in stainless steel and Inconel in diameters from 1/16 to 1/4 in. and lengths to 30 ft. Wire down to No. 30 AWG can be used. Thermocouple is available in Chromel-Alumel, iron-constantan, copper-constantan, and other materials. It is designed to measure temperatures to 2000 F at pressures to 50,000 psi, and can be



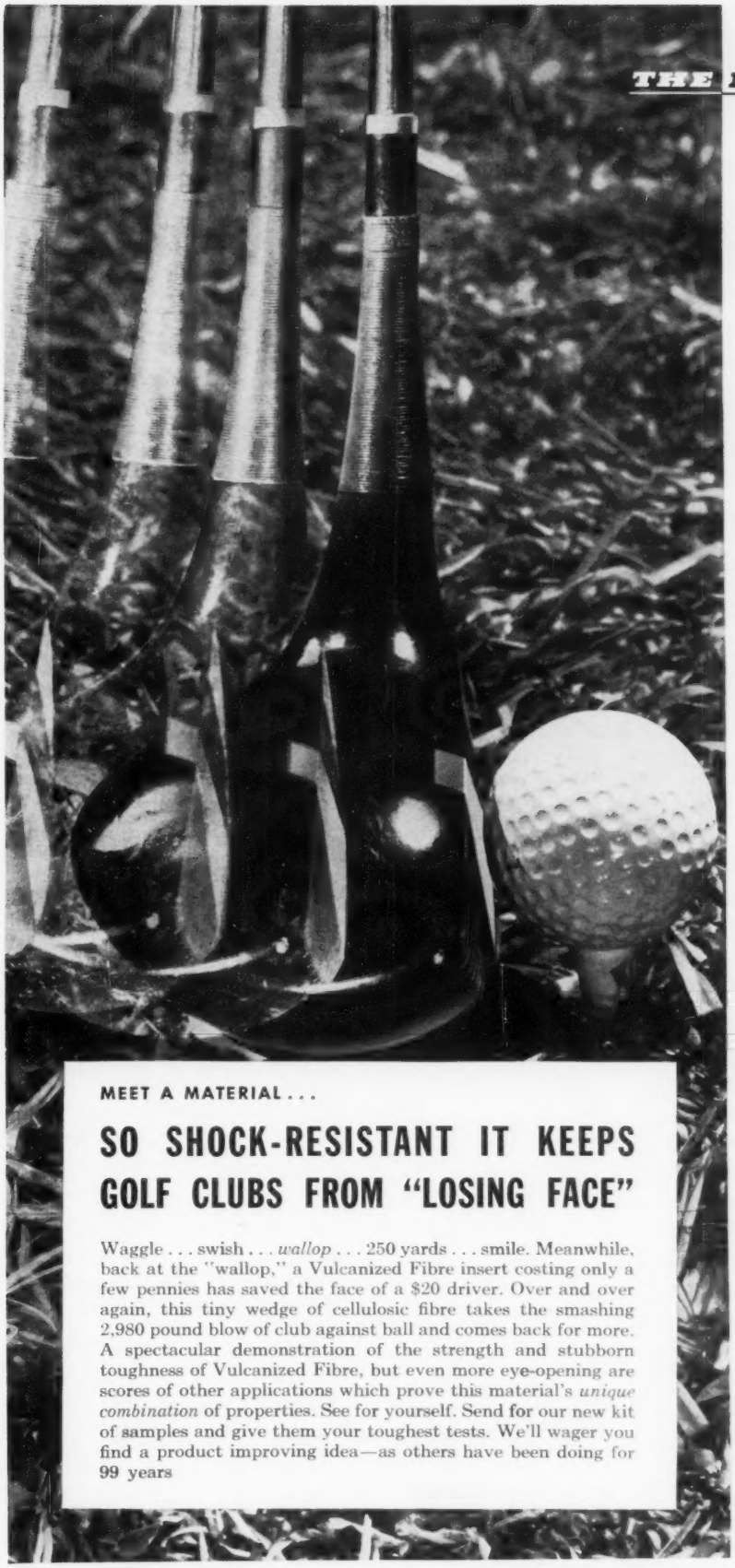
used for all applications of pencil-type units. Thermocouple meets ISA standards for accuracy. **Bristol Co.**, Waterbury 20, Conn. B

Circle 665 on Page 19

Miniature Nuts

for electrical and electronic equipment

Standard or special miniature brass nuts are for fastening and assembly use in miniaturized electrical and electronic equipment. They are tapped square with faces to Class



MEET A MATERIAL . . .

SO SHOCK-RESISTANT IT KEEPS GOLF CLUBS FROM "LOSING FACE"

Waggle . . . swish . . . *wallop* . . . 250 yards . . . smile. Meanwhile, back at the "wallop," a Vulcanized Fibre insert costing only a few pennies has saved the face of a $20 driver. Over and over again, this tiny wedge of cellulosic fibre takes the smashing 2,980 pound blow of club against ball and comes back for more. A spectacular demonstration of the strength and stubborn toughness of Vulcanized Fibre, but even more eye-opening are scores of other applications which prove this material's *unique combination* of properties. See for yourself. Send for our new kit of samples and give them your toughest tests. We'll wager you find a product improving idea—as others have been doing for 99 years

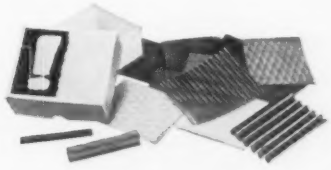
Here's the insert that takes a pounding

Yet the really impressive thing about this unique material is its almost unbelievable range of uses. For example: impact-resistant rail joint insulation for railroads; circuit breaker arc chutes; hard, glass-smooth shuttle armor and textile bobbin heads; dense, durable gears, cams and cutting blocks; lightweight, sanitary ligature reels; protective washers for hypodermic needles; flexible, tear-resistant backings for abrasive discs; oil- and solvent-proof parts of many kinds.

We take our own medicine. The light weight, glassy smoothness and long life of Vulcanized Fibre make it ideal for use in our own shock-resistant, sound-deadening Kennett Materials Handling Receptacles and Lestershire Textile Bobbins.

Among engineering materials, you'll find Vulcanized Fibre unique and surprisingly economical. It weighs only half as much as aluminum. It has outstanding arc resistance, low thermal conductivity, excellent resilience and high abrasion resistance. It absorbs sudden repeated shocks and impacts without failure. And it can even be formed or deep drawn into intricate shapes—as well as machined, polished, painted, embossed and combined with other materials, such as laminated plastic, aluminum, wood, rubber, asbestos or copper! It's available in many forms and sizes.

Send for samples today—and ask about the use of Vulcanized Fibre in any product that's giving you trouble. Dept. G-10.

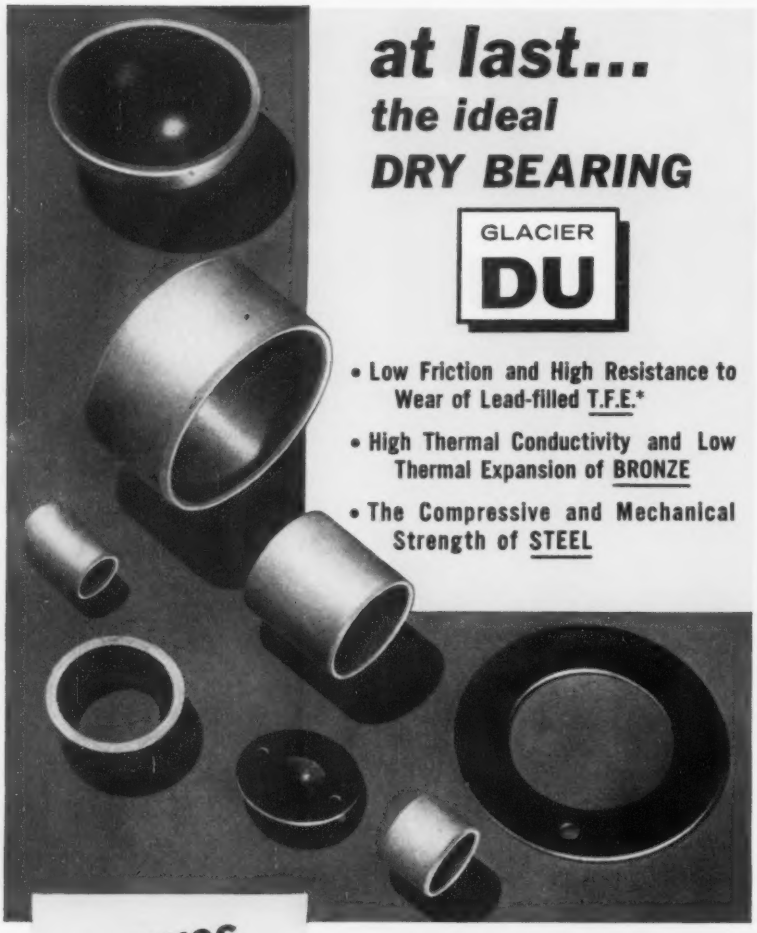


NATIONAL
VULCANIZED FIBRE CO

WILMINGTON 99, DELAWARE

In Canada:
NATIONAL FIBRE COMPANY OF CANADA, LTD., Toronto 3, Ontario

Circle 495 on Page 19



at last... the ideal DRY BEARING

GLACIER **DU**

- Low Friction and High Resistance to Wear of Lead-filled T.F.E.*
- High Thermal Conductivity and Low Thermal Expansion of BRONZE
- The Compressive and Mechanical Strength of STEEL

BEARINGS you can install and FORGET

Wherever bearing lubrication is a problem—in appliances, aircraft, automobiles, packaging, conveying and processing machinery, etc.—GLACIER DU offers an entirely new conception of dry bearing service.

- Highest compressive strength with no cold flow. (up to 23 tons per sq. in.)
- Extremely low friction — no slip-stick characteristics.
- 10 to 100 times the wear resistance of other self lubricated bearings.
- Solid T.F.E. fluorocarbon resin-lead lubricant, with temperature range from −320° F to +536° F, unaffected by hot water and detergents, solvents, alkalies, corrosive chemicals, abrasive atmospheres.

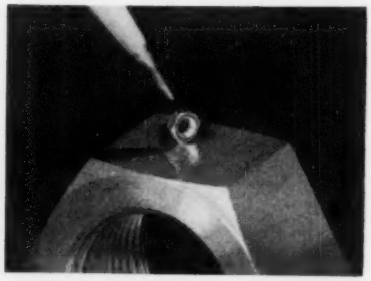
Investigate this new bearing material for the potential improvements it offers in your products. Ask your bearing manufacturer or write for engineering brochure to

SPECIAL PRODUCTS DEPT.
United States Gasket Company
Camden 1, New Jersey

*TEFLON, *du Pont Trademark*
FLUON, *I.C.I. Trademark*

United States Gasket *Plastics Division of* **GARLOCK**

2 tolerances, countersunk on both sides, burrless, degreased, and can be supplied in single or double-chamfered styles. Typical applications include precision instruments, transistorized radio and television sets, business machines, fractional and flea-horsepower motors, printed circuitry, and similar products. Nuts are available in standard hexagon, cap (open or closed end), and knurled-thumb types in a complete range of sizes. Miniature nut shown



with standard size nut measures 1/8 x 3/64 in. **Fischer Special Mfg. Co.**, 451 Morgan Ave., Cincinnati 6, Ohio. G

Circle 666 on Page 19

Teflon-Coated Foils

for capacitors and transformers

New Teflon-coated thin-foil dielectrics for capacitor and transformer applications have excellent thermal stability. Continuous machine operation can be maintained at 275-300 C temperatures. Tested at 200 v, an 0.3-mil coating on 1-mil copper tape revealed a pinhole density of 0.25 per sq ft, as compared with 22 pinholes per sq ft for bonded foil. Teflon-coated copper, stainless steel, and aluminum foils are available in a wide variety of widths and thicknesses. Foils are coated on one or both sides, and one or both edges. Density of coat can be rigidly controlled, and thicknesses from 0.0001 to 0.002 in. are possible. **Materials Research Corp.**, 47 Buena Vista Ave., Yonkers, N. Y. D

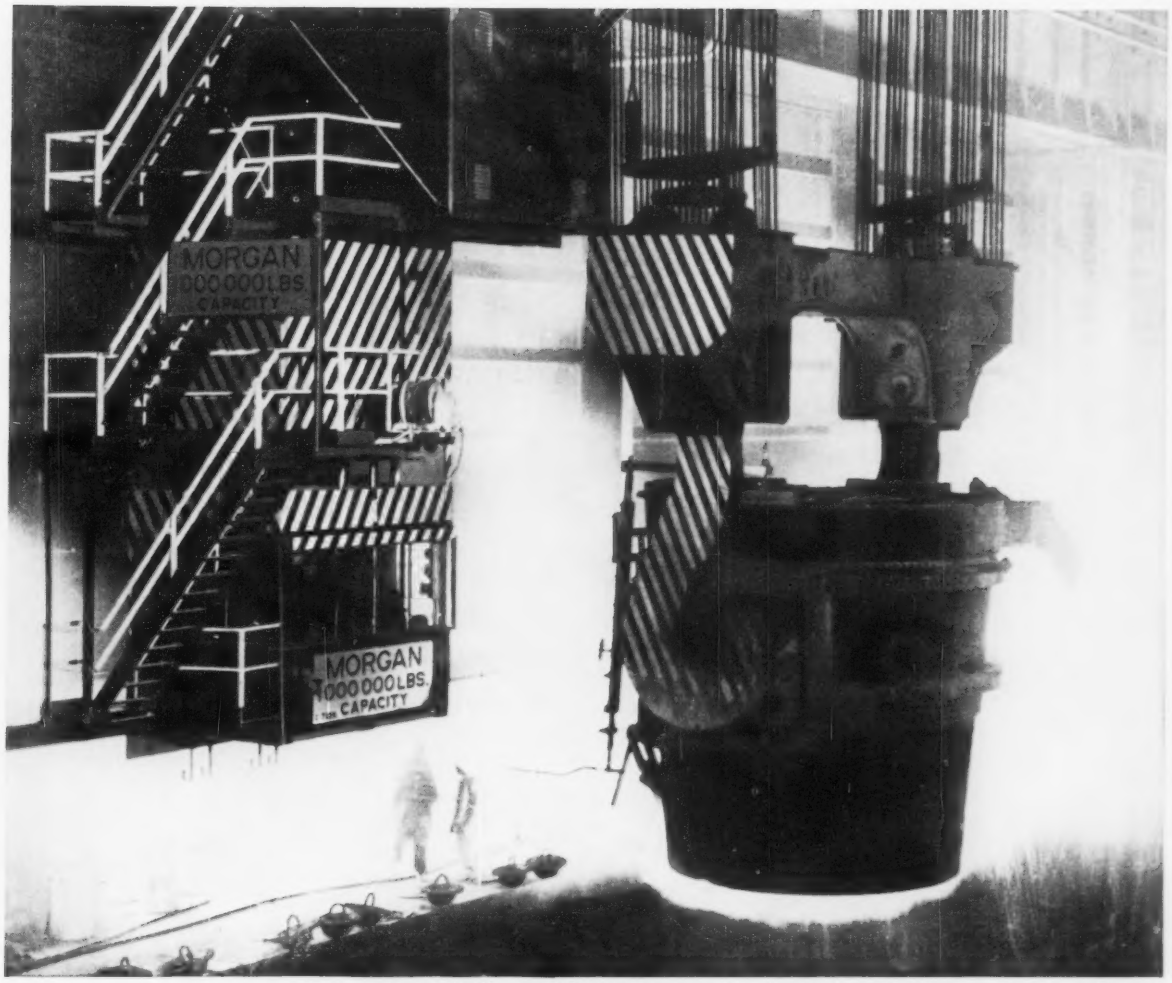
Circle 667 on Page 19

Variable Capacitor

miniature glass trimmer unit resists vibration and shock

New direct-traverse, expanding-core miniature variable capacitor provides greater range and higher sta-

Circle 496 on Page 19



Repeated million-pound loads in the intense heat from 375 tons of molten steel, cause no spalling or deformation of Rollway Bearings.

1,122,000 Pounds Ride on 68 Rollway Bearings

One of the largest in the world, this 500-ton Morgan-built ladle crane is Rollway equipped in many positions.

Sixty-eight maximum-type, solid-cylindrical bearings—mounted without inner races—lift and lower the 1,122,000-pound weight of the lifting beam, ladle hooks, ladle and white-hot steel.

Rollway Tru-Rol® type bearings are used in the two General Electric 360 HP – MD-620 Hoist motors which lift the weight of the ladle and its molten metal content.

The maximum-type bearings in the hoisting sheaves are mounted directly on the shaft without inner races, which greatly simplifies assembly for applications of this size.

Thrust bearings in the 25-ton and 75-ton auxiliary crane hooks are standard Rollway precision types with broad-area contact between rollers and plates to prevent Brinelling and assure freedom of rotation under the heaviest loads.

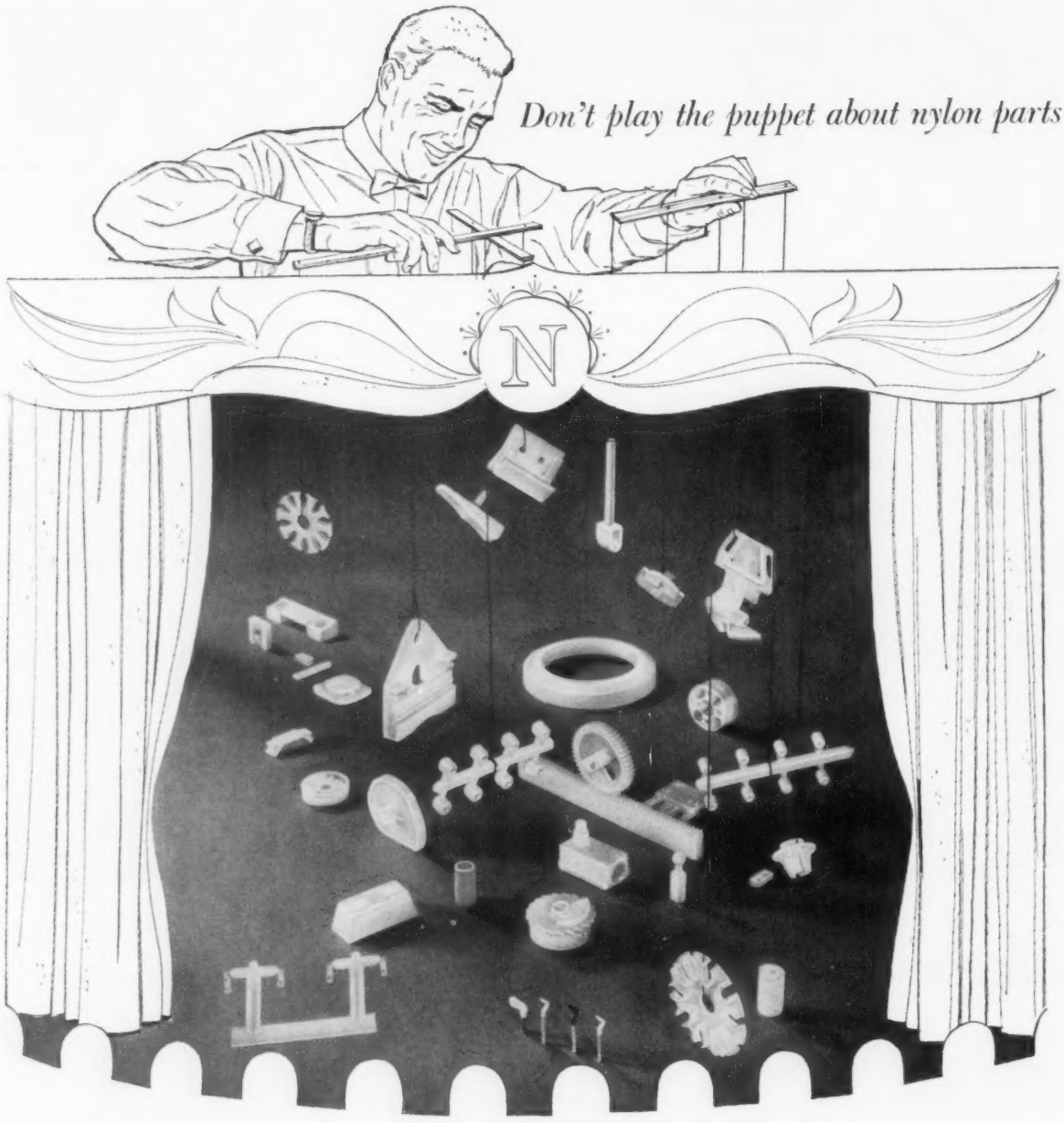
Sheaves ready for assembly on shaft and installation in lifting beam.

For bearings that accomplish the extraordinary in an ordinary manner, write, wire or 'phone Rollway Bearing Co., Syracuse 1, N.Y.

ROLLWAY® BEARINGS

ENGINEERING OFFICES: Syracuse • Boston • Chicago • Detroit • Toronto • Pittsburgh • Cleveland • Seattle • Houston • Philadelphia • Los Angeles • San Francisco

Circle 497 on Page 19



NOSCO "CAN DO" KNOWS NYLON MOLDING

Don't be misled by assuming that just any injection molder can mold nylon. It's an art and requires much skill and experience. Apply this 5-point test to qualify your potential nylon molders:

1. Do you know how to design molds to compensate for temperamental nylon shrinkage?

2. Does your gating control the behavior of nylon—for uniform fill, for optimum physical properties, for minimum waste of this costly material?

3. Do you have specialized machinery for molding nylon? Non-drool nozzles?

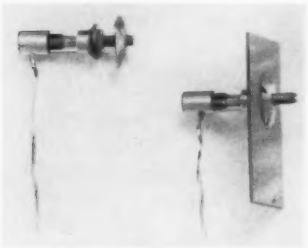
4. Do your heating cylinders provide sufficient stages for complete plasticizing without scorching?

5. Do you normalize after molding?

The one molder who can answer all of these questions with an emphatic "yes" is NOSCO—with more than 12 years of "can do" nylon molding experience.

It will pay you to ask for the advice of Nosco "Can Do" on your molded nylon parts. Why not write?

NOSCO plastics, inc. • erie 2, pa. *World's largest injection molding plant*



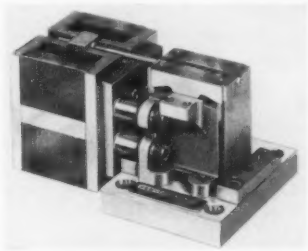
bility with less space and weight than previously. It maintains set value under extreme vibration and shock without excessive stress of component parts. Capacitor has excellent retrace characteristics with no tendency toward loopbacks. Full-floating piston assures positive mechanical alignment, eliminating run-out. Available in glass dielectric and silver-plated brass, unit is locked in a standard panel mounting, permitting easy micrometer adjustment. Diameter of 3/16 in. and 25/32 in. length give a range in excess of 0.5 to 5 mmf. **Atlas E-E Corp.**, 47 Prospect St., Woburn, Mass. B

Circle 668 on Page 19

Servo Valve

for pressures to 3000 psi

Single-stage, electrohydraulic three and four-way servo valve contains only two moving parts, a torque-motor armature and a "swing plate." Clearances and port seal sizes can be varied to suit application and fluid handled. Spring-steel swing-plate supports respond instantly to low torque-motor forces. Because torque-motor armature pivots on a torsion shaft, valve automatically centers in event of power failure. Compensating cap equalizes hydraulic forces to maintain selected clearances for operation above 500 psi. Open or enclosed valves can be gasket mounted, with pipe-tap subplates also available. Flow rate is 4 gpm at 250 psi, and 8 gpm at 1000 psi pressure drop



WHY TRY TO SOLVE YOUR GEAR PROBLEMS ALONE?

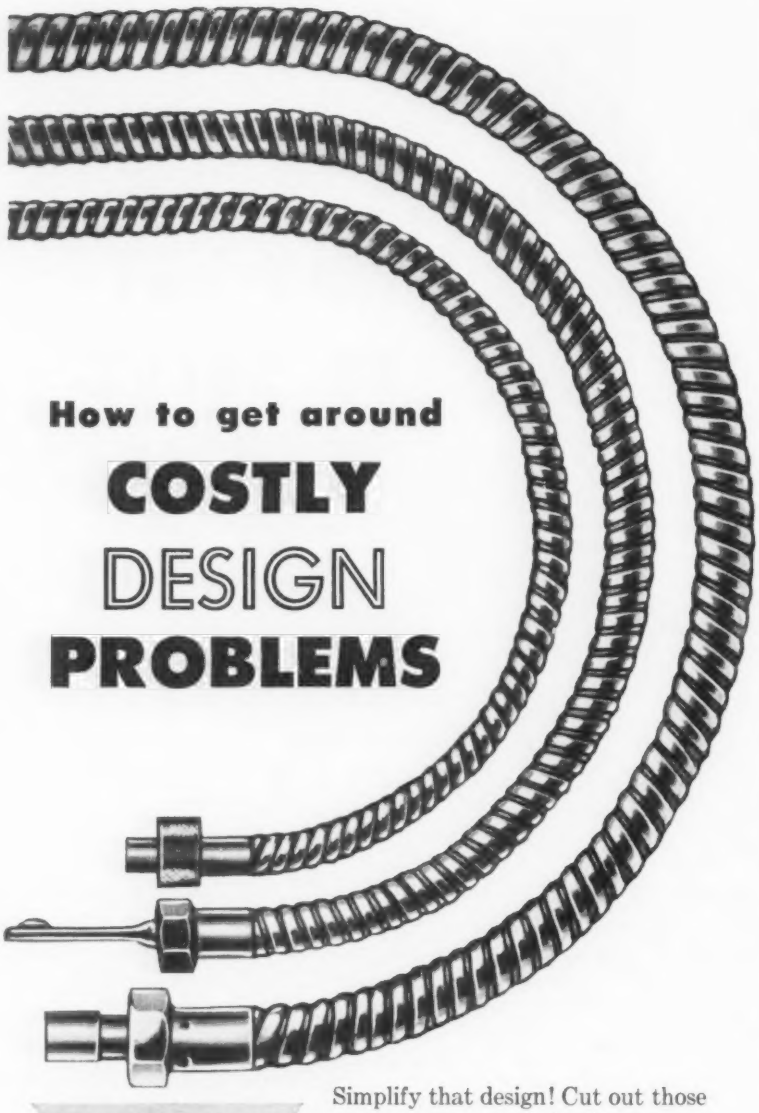
PERKINS can custom-cut a precision gear to fit your exact needs...make you a gear that guarantees full capacity and trouble-free performance. Many gear-makers promise a precision gear — Perkins delivers precision . . . always. Fifty-two years of gear-making for aircraft, automotive and instrument manufacturers assure top quality. Extensive facilities, modern equipment, rigid production and quality controls produce gears consistently uniform in tolerance with a burr-free micro finish. Perkins quality eliminates production delays and costly rejects for you . . . Perkins gears wear longer, cost you less in the long run. Ask us to quote on your next gear requirement. Then judge for yourself.

YOURS ON REQUEST
Folder showing custom gears Perkins has made (from various materials) for aircraft, automotive, precision instruments, home appliances, portable and machine tools, and other products. Includes Perkins facilities for producing various gear types and sizes. *Write today.*

PERKINS
MACHINE AND GEAR CO.

Dept.33, West Springfield, Mass.
Telephone: REpublic 7-4751

Circle 499 on Page 19



How to get around
COSTLY
DESIGN
PROBLEMS

Custom designed flexible shafting for:

AIRCRAFT APPLICATIONS
APPLIANCES
INDUSTRIAL MACHINES
RADIO AND ELECTRONICS
SPECIAL APPLICATIONS

Simplify that design! Cut out those unnecessary gears! Avoid exposed moving parts! Forget about misalignment problems! Save space and weight! Cut assembly costs!

These are some of the ways Robertshaw Flexible Shafting can help you improve new or existing equipment requiring *power drives, remote controls* or *couplings*. Easier to design, install, maintain.

Write for the newest and most comprehensive flexible shafting data in the industry . . . Catalog 3310.

Mr. Controls®
Robertshaw-Fulton
CONTROLS COMPANY

FLEXIBLE SHAFT DIVISION • 110 Summit Ave., Chatham, N.J.

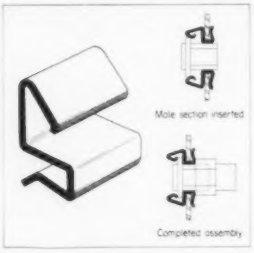
across valve. Valve is for supply pressures to 3000 psi. **Oilgear Co.**, 1570Q W. Pierce St., Milwaukee 4, Wis. K

Circle 669 on Page 19

Electrical-Connector Clip

provides fast vibrationproof fastening

New Speed Clip is designed for through-panel application of solderless multiple-connector electrical terminals. Pair of fasteners are snapped onto panel, and male section of terminal connector is inserted into rectangular panel hole. As it passes through, spring legs of clips compress and spring out again over flanges projecting from either side of connector. Flanges prevent connector from passing completely



through panel and clips prevent it from being pushed out when other half of connector is applied. Removal of connector is accomplished by compressing fastener spring legs with pliers. Clip provides fast, vibrationproof fastening, and can be used on any similar light application. **Tinnerman Products Inc.**, P. O. Box 6688, Cleveland 1, Ohio. F

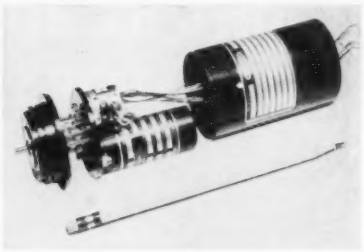
Circle 670 on Page 19

Rotating Servo Components

in miniature turret packages

Precision rotating servo components are assembled in miniature turret packages which can handle vibration and shock. Motor can drive more than one component, each at the same or different gear ratios, and output shaft makes possible easy connection to other components or subassemblies. Photo shows a typical package containing a size 11 motor-tachometer, gearhead, and potentiometer, encased in a package less than 5 in. long, with nominal OD of 2¼ in. Other

Circle 500 on Page 19



servo components can be added as needed, as well as clutch and limit stops. **Mechatrol Div., Servomechanisms Inc.,** 1200 Prospect Ave., Westbury, L. I., N. Y. D

Circle 671 on Page 19

Conveyor Belt

of glass fabric is Teflon coated

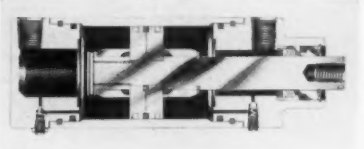
New Teflon-coated, glass-fabric conveyor belt is available for lightweight industrial applications. Belt has excellent abrasion resistance and physical strength, has smooth surface, and exhibits good antiadhesive, antifriction qualities. It remains flexible and nonbrittle over a temperature range of −100 to 525 F. Belt is available in either 0.005 or 0.010-in. thick single-ply type, in widths up to 36 in. with lap splice. It has safe working stress of 5 lb per in. of width for 0.005-in. and 10 lb per in. of width for 0.010-in. material. **Quaker Rubber Div., H. K. Porter Company Inc.,** Tacony and Comly Streets, Philadelphia 24, Pa. E

Circle 672 on Page 19

Hydraulic Cylinder

incorporates new piston-ring seal

New 350-psi hydraulic cylinder handles a variety of basic service applications where an economical hydraulic-power unit is required. Cast-steel mounts are integral with head and rod caps. Head and mount unite with cylinder wall by means of an internal locking key, permitting full 360-deg rotation of pipe parts for universal orientation.



Precision Seals

engineered specifically for your product

SIMPLE
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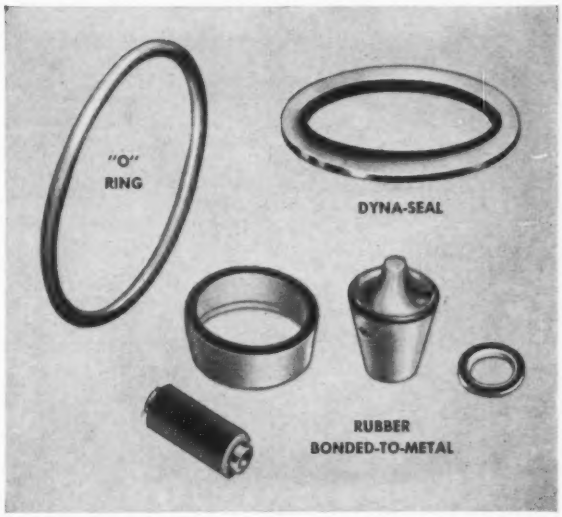
LOW COST
SPACE SAVING



"O" RINGS—Over 100 Inspections and Tests to assure dependable, accurate "O" Rings to meet all specifications. Prompt shipments from stock.

DYNA-SEALS—For face-to-face sealing. This rubber bonded-to-metal seal eliminates special machining, cuts assembly costs and is reusable. Sizes for No. 5 screw to 1¼" bolt.

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Circle 501 on Page 19

'DIAMOND H'
SERIES W

General Purpose Relays

MEASURE ONLY:
1½" x 1½" x 1⅞"

BUT CARRY:
to 25 A. resistive at 115-230 V., A. C.; 1 h.p., 125 V., 2 h.p., 250 V., A.C.; D. C. and other higher ratings on request.

CONTACTS:
DPDT, Double Break-Double Make (Form Z). Special arrangements and sequence on request.

MOUNTINGS:
Socket, panel and sidewall arrangements standard; others to meet special needs.

"Diamond H" engineers are prepared to work out variations of these rugged, dependable relays to meet your specific requirements in such applications as **automation controls, appliances and air conditioning equipment,** or what you will. Just ask.

THE
HART
MANUFACTURING COMPANY
118 Bartholomew Avenue
Hartford, Conn.
Phone Jackson 5-3491

Circle 502 on Page 19

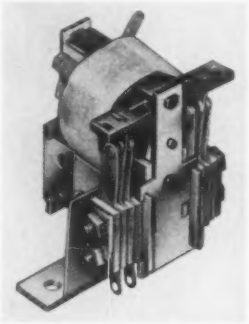
New piston design features a leak-proof O-ring located between two low-breakout, double-acting piston rings. Meehanite rod bearing is full 1:1 ratio. Bore sizes from 1½ to 8 in. are available, with strokes to 18 ft. **Carter Controls Inc.**, 2800 Bernice Rd., Lansing, Ill. J

Circle 673 on Page 19

Magnetic Toggle Relay

operates in 3 millisec from ac or dc voltage

Without mechanical latching or electrical holding power, new magnetic toggle relay is held in either of two normal positions by magnetic detenting. With the same coil, it operates in as little as 3 millisec from ac or dc voltage of 1 to 120 v. Unit incorporates a permanent mag-



net and a wound rotating armature. Relay toggles when armature polarity is changed. There are two normal positions, with no unenergized position. Relay provides a variety of inputs with any one coil. **American-Monarch Corp.**, 2801 37th Ave. N.E., Minneapolis 18, Minn. J

Circle 674 on Page 19

Diesel Engines

air-cooled units operate in ambient temperatures to 140 F

Models SL1, 2, and 3 air-cooled diesel engines are available with 1, 2, and 3 cylinders, with rating of 4¼ bhp per cylinder at 1800 rpm. Three-cylinder model (shown) has totally enclosed, compact design, and is adaptable as a prime mover for all applications such as pumps, compressors, generators, and hoists. Efficient cooling is provided by an impeller which is integral with the flywheel, through a fan shroud and ducting system distributing air

LimiTorque
ACTUATORS

for
UP OR DOWN
OR ROTARY
POSITIONING

LimiTorque actuators are efficient, sensitive, automatic heavy duty power-operated units *for positioning machine parts or other assemblies requiring Linear or Rotary Motion.*

LimiTorque is an electro-mechanical mechanism, using motor power through highly efficient and precision gearing, to impart Linear or Rotary motion . . . Limit switches are available to limit the travel in either direction—Thrust and Torque responsive switches control thrust or provide emergency shut-off. With LimiTorque it is possible to control full travel accuracy to within .2%—LimiTorque is easily and accurately controlled by the mere "push of a button".

LIMITORQUE IS BACKED BY 30 YEARS' EXPERIENCE IN MOTORIZING ALL TYPES OF VALVES—WHY NOT CONSULT US REGARDING ANY PROBLEM YOU MAY HAVE INVOLVING LINEAR ACTUATION; OUR ENGINEERS CAN NO DOUBT HELP YOU SOLVE THAT PROBLEM.

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INDUSTRIAL GEARS & SPEED REDUCERS
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FLUID MIXERS • FLEXIBLE COUPLINGS
Limitorque Corporation • Philadelphia

Circle 503 on Page 19

Why pay for heavy aluminum sections

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AND CUT YOUR COST PER LINEAL FOOT

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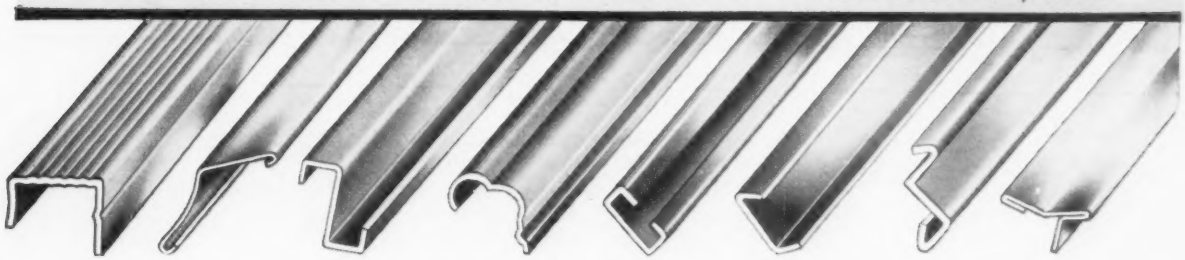
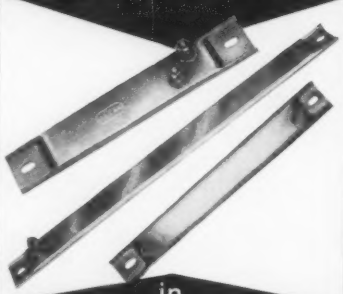


Circle 504 on Page 19

Solve Your
HOT PROBLEMS
with
VULCAN
VERSATILITY



in
STRIP
HEATERS

Vulcan Electric Strip Heaters are especially designed for contact heating of dies, platens, molds, or any items with flat surfaces to which elements may be clamped; also as air heating source for ovens, air ducts, dryers, etc.

You have a wide choice of standard seamless one-piece sheaths — steel for sheath temperature to 750°F, Chromalloy for sheath temperatures to 1200°F; lengths — 8" to 42½" (or longer); wattage — 150 to 1500 watts (or higher); rugged non-oxidizing terminal posts.

When your hot problems call for *unusual* specifications, you get a speedy solution through *Vulcan Versatility* in engineering and production. Standard or special — Vulcan is ready to supply your complete needs in low-cost, efficient heating units — strip, cartridge, tubular, immersion, finned, band, and ring heaters. Send coupon for catalog and prices.

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Please send catalog and price information on Vulcan Electric Heaters. I am especially interested in (check):

☐ Strip ☐ Tubular
☐ Immersion ☐ Finned
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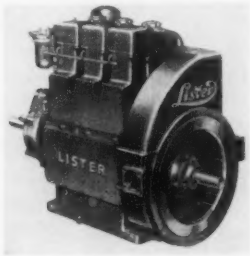
NAME & TITLE .....
COMPANY .....
STREET & NO. .....
CITY & STATE .....

Circle 505 on Page 19



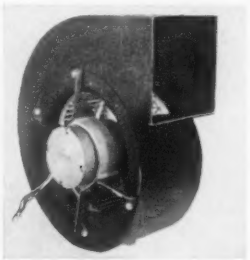
evenly through deep fins on all cylinders. Full power is maintained under load in ambient temperatures to 140 F. Motors start by hand from cold in temperatures below zero and require no preheating systems. **Lister - Blackstone Inc.**, 42-32 21st St., Long Island City 1, N. Y. D

Circle 675 on Page 19

Cooling Blowers

have motors mounted inside impeller

New F-frame cooling blowers are used in large commercial computers to maintain normal power-supply temperatures. Motors are mounted inside the impeller to reduce overall size and obtain cooling effect on motor itself. Units are available for military or commercial use in 115 or 220 v, 1 or 3-cycle, 60



or 400-cps applications. Motor shown is 3-13/16 in. in diam and is driving an 8½-in. squirrel-cage impeller. **Air-Marine Motors Inc.**, 369 Bayview Ave., Amityville, L. I., N. Y. D

Circle 676 on Page 19

Photoconductive Cell

has high illumination sensitivity

No. 7163 cadmium-sulfide photoconductive cell is designed for use in light-operated relay applications in industry, and for street-lighting control. Direct relay operation,

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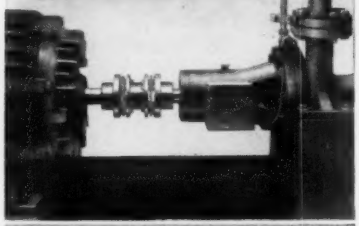
FLEXIBLE COUPLINGS
Protect your PUMPS
and other
Indispensable
MACHINERY!



NO LUBRICATION
NO MAINTENANCE
NO WEARING PARTS

Future maintenance costs and shutdowns are eliminated when you install Thomas Flexible Couplings. These all-metal couplings are open for inspection while running.
They will protect your equipment and extend the life of your machines.
Properly installed and operated within rated conditions, Thomas Flexible Couplings should last a lifetime.

UNDER LOAD and MISALIGNMENT ONLY THOMAS FLEXIBLE COUPLINGS OFFER ALL THESE ADVANTAGES:

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- No Lubrication
- No Wearing Parts
- No Maintenance

Write for Engineering Catalog

THOMAS FLEXIBLE
COUPLING CO.
WARREN, PENNSYLVANIA, U.S.A.

Circle 506 on Page 19

without use of an amplifier, is possible in most applications because of extremely high illumination sensitivity. Spectral response covers approximate range from 3300 to 7400 angstroms, with maximum response at about 5800 angstroms. Unit is enclosed in a metal envelope with glass window and is hermetically sealed to permit operation under conditions of high humidity. It has minimum photosensitive area of 0.54 x 0.65 in., maximum diam of 1.26 in., and maximum over-all

length of 0.90 in. It is equipped with two pin-terminals. **Tube Div., Radio Corp. of America**, Harrison, N. J. D

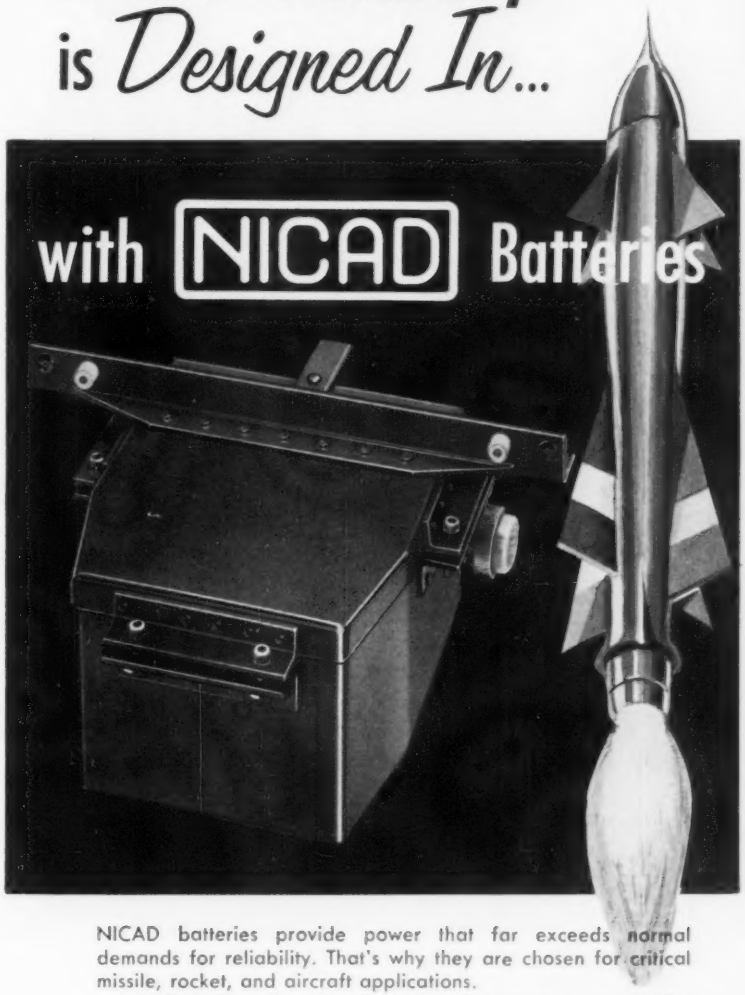
Circle 677 on Page 19

Synchronous Motor

for heavy-duty continuous operation

RSM instantly reversible, 80 oz-in., continuous-duty synchronous motor is enclosed in a case measuring 2½ in. in diam by 1¾ in. long. Designed for heavy-duty operation, it maintains timing accuracy in both clockwise and counterclockwise directions. Shaft rotation can be reversed as often as required without damage to motor. Output speeds range from 2/3 to 3600 rpm. Motor weighs only 14 oz and has operating temperature rise of 40 C above ambient. It operates on 115 v at 60 cycles. Motor remains operative in a temperature range

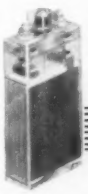
Proven Reliability is *Designed In...*



NICAD batteries provide power that far exceeds normal demands for reliability. That's why they are chosen for critical missile, rocket, and aircraft applications.

NICAD batteries give better performance over a wider temperature range than other types of batteries . . . will not freeze in any state of charge . . . give off no corrosive fumes. Their compact size—smaller and lighter than conventional batteries—conserves the space so valuable in the confined power systems of missiles and aircraft. Rugged construction makes them capable of withstanding severe shocks and vibration. And their long life and virtually maintenance-free operation give long-term economy unmatched by any other type of battery.

Find out how you can design exceptionally reliable and economical power into your company's new or redesigned products. Request detailed information. ***NICAD Division, Gould-National Batteries, Inc.***, Easthampton, Mass. Offices in New York, Chicago, San Francisco.



NICAD **ALKALINE STORAGE BATTERIES**

Circle 507 on Page 19

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ELECTRICAL ENGINEERS

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Here's your chance to break in on a growing field where aggressive creative work is really appreciated. MACHINE DESIGN has a staff opening for an engineer with an interest in both engineering and editorial work. This job provides stimulating contact with many engineering areas plus opportunity to grow and progress as a specialist in a particular branch of design engineering.

Some evidence of design engineering experience is necessary, and an ME or EE degree would be desirable. Writing ability and interest are also required, although a heavy background of editing or writing is not essential.

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from − 40 to 105 C and withstands 100-g shock without damage. **Hurst Mfg. Co.**, Princeton, Ind. J

Circle 678 on Page 19

Lockwasher

has positive locking and sealing action

Dubo lockwasher of Nylon 6 has excellent resistance to wear, shock absorption, corrosion and chemical resistance, nonflammability, and high flexural strength. It is especially useful for electrical insulation, or for control of electrolytic corrosion between dissimilar metals. When nut is tightened, ID of washer grips into threads of nut and bolt to seal this junction against

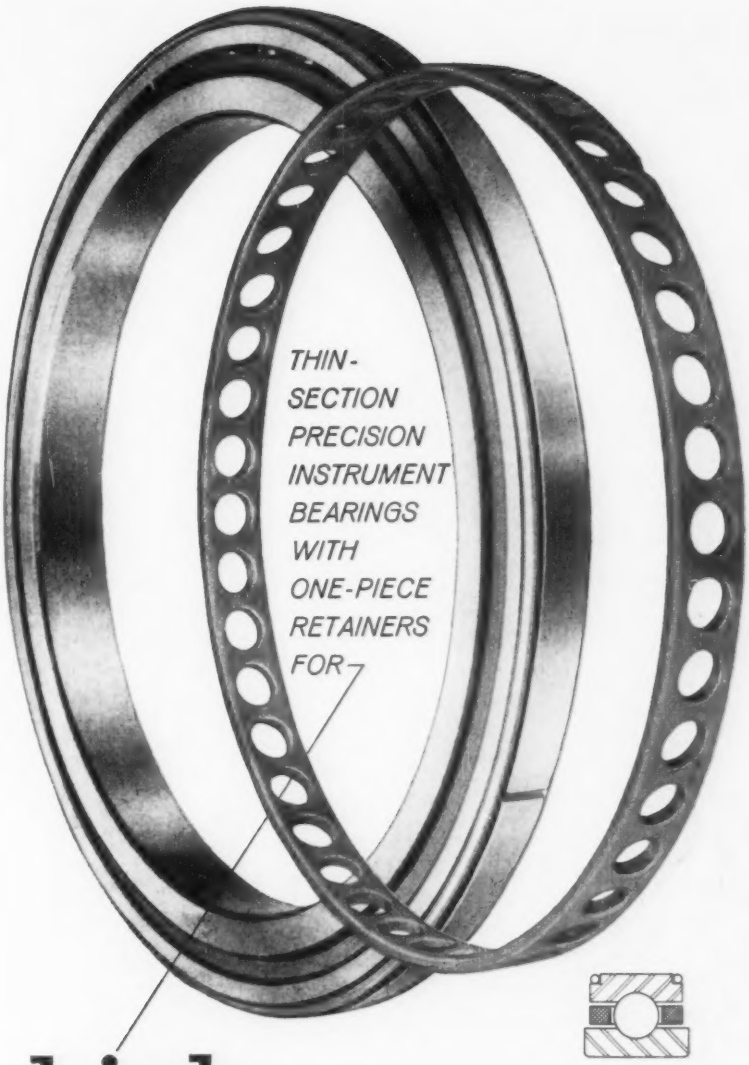
leakage, while OD flows over outer edges of nut, sealing and locking it. The positive locking and sealing action is unaffected by vibration or shock. Unit, which has no threaded parts, can be reused without loss of holding power. **Nylogrip Products**, 449 Watertown St., Newton, Mass. B

Circle 679 on Page 19

Panel Meters

sealed units resist vibration and shock

Sealed electrical indicating-panel meters have external zero adjusters, and meet requirements of MIL-M-6B and MIL-M-10314A. Bezel of die-cast aluminum harmonizes with military and commercial electronic equipment. Locking seal is employed between case and bezel, and positive neoprene gasket sleeve effectively seals zero adjuster from moisture leakage. Entire movement is isolated in rubber and glass window is double strength to provide maximum protection from shock and vibration. Meters are available in dc and ac types in 2½ and 3½-in. sizes. A 4½-in. size



high *speeds, thrust loads, radial loads*

plus **low** *torque*

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A DIVISION OF MPB, INC.

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NEW HAMPSHIRE

Circle 509 on Page 19

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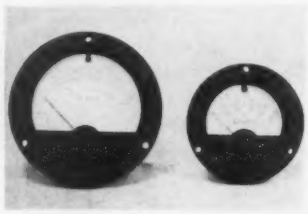
Circle 510 on Page 19



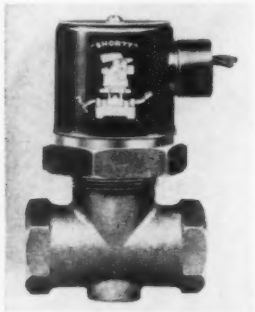
will soon be available. WacLine Inc., 35 S. St. Clair St., Dayton 2, Ohio. G

Circle 680 on Page 19

Solenoid Valve

is pilot-operated, two-way unit

Shorty all-purpose, two-way solenoid valve is 4¾ in. high x 3 in. wide, with height from top to line of 3 13/16 in. Constructed of cast bronze, valve has a wide variety of uses. Applications are for air and gases to 250 psi, water to 150, oil to 75, and steam to 25 psi. Pilot-operated, valve can be kept open with a pressure differential as low



as 5 psi. Unit has stainless-steel pilot, unbreakable, stick-free piston rings, and replaceable resilient seats. Four pipe sizes are ¼, ⅜, ½, and ¾ in. Atkomatic Valve Co. Inc., 545 W. Abbott St., Indianapolis 25, Ind. J

Circle 681 on Page 19

Polyvinyl-Chloride Plastics

for pipe and contour extrusion uses

Two new rigid polyvinyl-chloride plastics are free flowing and provide good gloss characteristics on contour extrusions and sheet for vacuum forming. They are available particularly for pipe and contour extrusion applications. QGD-5020 is a high-impact plastic which has an Izod impact strength of 20

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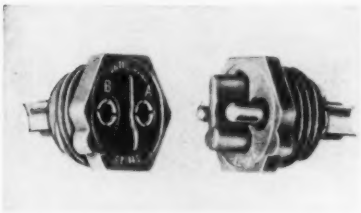
Circle 511 on Page 19

to 30 lb per in. of notch. The compound provides ease of fabrication, and exhibits good weatherability and chemical resistance. Compound QGD-5010 withstands contact with many strong acids, alkalies, metallic and ammonium salts, alcohols, and aliphatic hydrocarbons, and is designed for pipe to be used where high chemical resistance is required. **Bakelite Co., Div., Union Carbide Corp.**, 420 Lexington Ave., New York 17, N. Y. C

Circle 682 on Page 19

Miniature Connector

is high-current hexagonal type



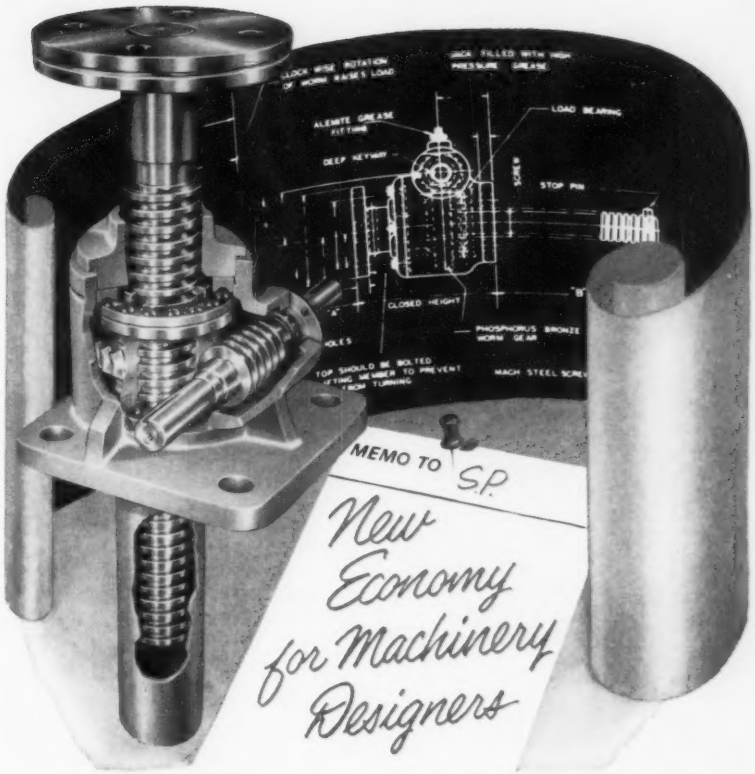
Series C2 high-current miniature hexagonal two-contact connector is suitable for high-altitude applications requiring high breakdown voltages under critical environmental conditions. Polarizing barrier between two pin contacts provides a long peakage path and permits use of high voltage (4000 v rms) and 30-amp current without breakdown. Vibration ring with matching detent-action lock-spring clamps and locks plug and socket against accidental disconnect. **Electronic Sales Div., DeJur-Amsco Corp.**, 45-01 Northern Blvd., Long Island City 1, N. Y. D

Circle 683 on Page 19

Small Motor

provides high torque

Redesigned Type A ac motor provides higher efficiency without increase in over-all dimensions. It is used where space and size are critical, and low noise, high torque, and long life are required. Fan blades from 2 to 4 in. can be attached for use in deodorizers, electronic equipment, and blowers. Reroll chart drives, fans, stirrers, and gear-train drives are additional applications for the unit. Variations in mount-



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The economies of standardized production now can be realized by machinery designers who use Duff-Norton worm gear jacks for accurate positioning of loads weighing as much as several hundred tons. After 25 years of experience and hundreds of custom designs, Duff-Norton engineers have produced a standard line of eight jacks ranging from 2 to 100 tons in capacity which will meet almost any requirements. When jacks are used in an arrangement, added economy can be realized in raising unevenly distributed loads, since all models now have a uniform raise which permits jacks of varying capacities to operate in unison.

Worm gear jacks are purely mechanical devices, and they can hold heavy loads in position indefinitely without any creep. Functioning as components of machinery or equipment, they can raise or lower loads, apply pressure or resist impact. Worm gear jacks can be furnished with raises up to 24 inches, and they will provide exactly the same raise for years without adjustment.

Thousands of these jacks are in use on feeding tables, tube mills, welding positioners, pipe cut-off and threading machines, testing equipment, aircraft jigs, loading platforms, rolling mills, conveyor lines, and numerous other types of equipment. If you have a positioning problem, write for complete information, requesting Bulletin AD-66-V, which includes drawings and full specifications.

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DUFF-NORTON JACKS
Ratchet, Screw,
Hydraulic, Worm Gear

DUFF-NORTON

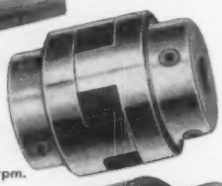
COFFING HOISTS
Ratchet Lever
Hand Chain, Electric

Circle 512 on Page 19

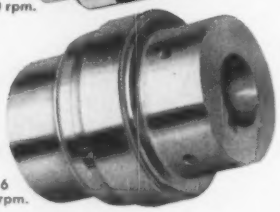
Lovejoy

Flexible Couplings

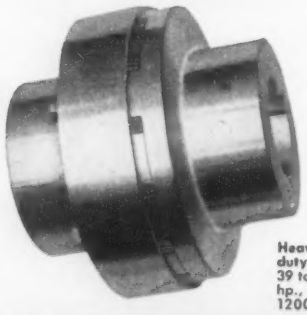
Light Duty—
.003 to .05 hp.,
100 rpm.



Standard duty—
.05 to 40
hp., 1750 rpm.



Medium heavy duty—
2.6 to 156
hp., 100 rpm.



Heavy duty—
39 to 4250
hp.,
1200 rpm.

from .003 to 4250 H. P.
⅛ In. to over 9½ In. Bores

- **Can be installed in minutes**
- **Align with a straight edge—no gauges required**

The most trouble-free couplings you can install on your equipment . . . no complicated mechanisms, all parts open for inspection, reversible cushions, no lubrication required. Immediate delivery from stock in any quantity.

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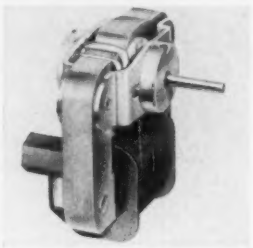
Circle 513 on Page 19



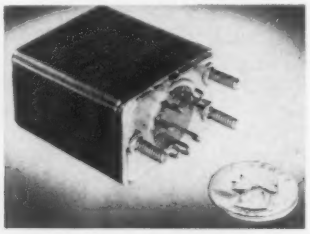
ing and rotation are available. **Barber-Colman Co.**, Dept. 766, Rockford, Ill. K

Circle 684 on Page 19

Time-Delay Relay

miniature unit has a transistor control circuit

New time-delay relay for airborne or ground use offers instantaneous recycling. It is preset to give delay times from 50 millisec to 50 sec. Unit has a transistor control circuit, with a relay contact as the only moving part. Weighing 4 oz, the miniature unit is accurate from 18 to 32 v dc, and in ambient temperatures from − 55 to 71 C. Designed in accordance with military specifications, relay uses printed-circuit construction. It withstands shock of 50 g for 11 millisec and



vibration of 20 g to 2000 cps. Contact rating is 5 amp resistive, and contacts are double pole, double throw. **Master Specialties Co.**, 956 E. 108th St., Los Angeles 59, Calif. L

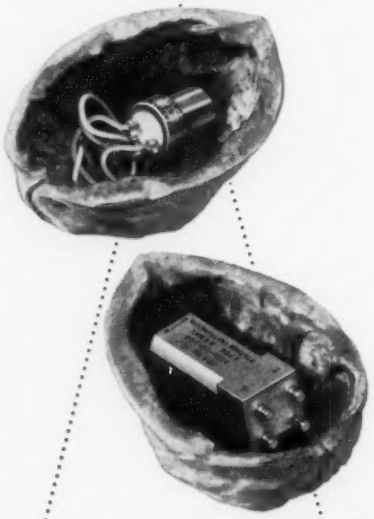
Circle 685 on Page 19

Speed Reducers

have reduction ratio from 66 2/3:1 to 4466:1

New double-reduction, hollow-shaft, worm-gear speed reducers provide a complete range of reduction ratios from 66 2/3:1 to 4466:1, with outputs from 0.04 to 2.55 hp and torques from 1473 to 7678 lb-in. Available in both torque arm (shown) and flange-mounted mod-

miniaturization in a nutshell



* **STATHAM MODEL P222** flush diaphragm pressure transducers.
DIMENSIONS: .25" diameter x .47" long.
WEIGHT: 3 grams, approximately.
RANGES: 0-10 to 0-200 psia, psig, or psid; ±5 to ±25 psid.
NON-LINEARITY & HYSTERESIS: Not more than ±1% fs.
TRANSDUCTION: Resistive, complete bridge; Statham unbonded strain gage.

* **STATHAM MODEL A52** linear accelerometer.
DIMENSIONS: .32" wide x .35" high x .84" long.
WEIGHT: 8 grams, approximately.
RANGES: ±5 to ±100 g.
NON-LINEARITY & HYSTERESIS: Not more than ±1% fs.
TRANSDUCTION: Resistive, complete, balanced bridge; Statham unbonded strain gage.

Statham's accurate, reliable line of pressure transducers and accelerometers are designed to meet the exacting requirements of today's missile and supersonic aircraft programs. Let us assist you with your instrumentation problems.

*Model shown actual size.

Complete data are available upon request.

Statham
INSTRUMENTS, INC.
12401 W. Olympic Blvd., Los Angeles 64, California

Circle 514 on Page 19

els, units are installed on keyed shaft of driven unit and require no foundation. Flange-mounted unit is bolted to driven machine to form a single rigid, close-coupled unit. Torque-arm type allows for fast adjustment of drive-belt tension at any time by turnbuckle, rather than moving motor. Both units are pro-

vided in all standard assemblies. **Winsmith Inc.**, 6 Elton St., Springville (Erie County), N. Y. F

Circle 686 on Page 19

Extruded Vinyl Foam

has high strength and abrasion resistance

Cipco Foam is a new material having uniform, small cell structure with a controlled mixture of open and closed cells. Basic vinyl formulation can be varied to accommodate any particular application requiring unusual or special profile shapes. Compatibility, high-strength, and abrasion resistance suit material for a variety of uses including fillers in extruded shapes, protective packaging, or permanent gasketing for industrial applications in which flow of material is desirable. Material also has excellent flame resistance, high shock absorption, long heat age life, and tensile strength of 108 psi. Basic material is available in a standard line of round, continuous lengths with diameters from $\frac{1}{8}$ to 1 in. Foam is also available in a wide range of profiles and colors for industrial applications. **Carolina Industrial Plastics Div., Essex Wire Corp.**, Dept. A, Mt. Airy, N. C. A

Circle 687 on Page 19

Coupling and Valve Unit

permits untended tank loading

New self-sealing coupling and shut-off-valve unit permits untended liq-

Circle 515 on Page 19→

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BALL BUSHINGS

Adjustable Diameter BALL BUSHING for Zero Clearance

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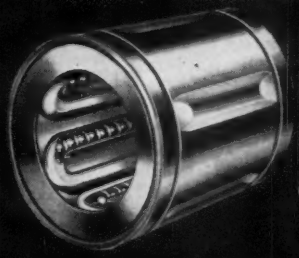

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Sliding linear motions are nearly always troublesome. Thousands of progressive engineers and designers have solved this problem by application of BALL BUSHINGS on *guide rods, reciprocating shafts, push-pull actions,* or for support of *any mechanism that is moved or shifted in a straight line.*

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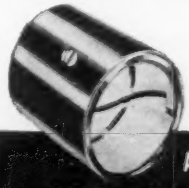
LONG LIFE · LASTING ALIGNMENT

The various types cover a shaft diameter range of ¼" to 4". Small sizes available in Stainless Steel. Write for literature and name of our representative in your city.



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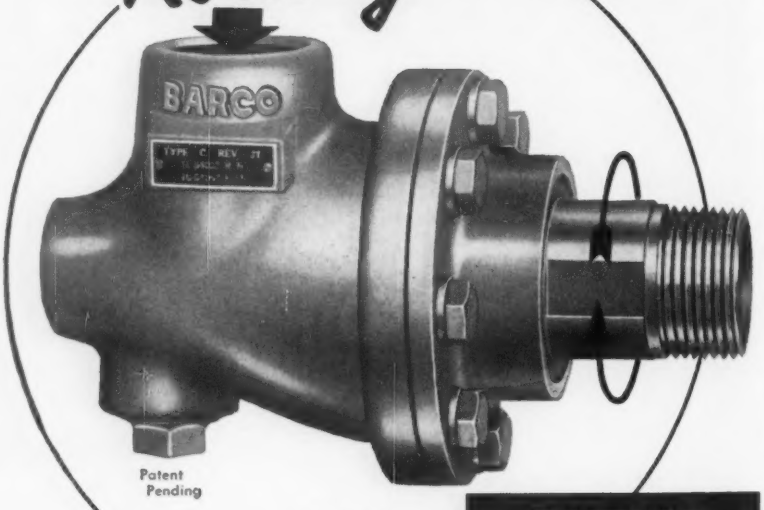

SIZES
½" ¾" 1" 1¼"
1½" 2" 2½" 3"

NEW BARCO TYPE C Rotary Joint

for

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AIR or GAS

"SUPER" Performance and Construction —at no extra cost!

"CRACK-FREE" CHROME PLATED SLEEVE—A standard Barco feature. "Crack-free" chrome on rotating sleeve minimizes corrosion, friction, wear. Stainless steel spring also standard.

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NO LUBRICATION NEEDED—Spherical seating seal self-adjusting for wear.

WIDE SPACED BEARINGS—Two, instead of one . . . increased bearing area.

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In Canada: The Holden Co., Ltd., Montreal

uid transfer for any large tank-loading operation. Coupling permits loading of tanks to a predetermined level from a supply hose, and valve automatically stops flow. Both coupling halves seal automatically upon disconnection, preventing spillage and overflow. Coupling is recommended for use with water, diesel fuel, gasoline, lubricating oil, kerosene, jet fuel, turpentine, and most petroleum-based products. **Aeroquip Corp.**, Jackson, Mich. H

Circle 688 on Page 19

Floating-Hub Caster

for light-duty applications

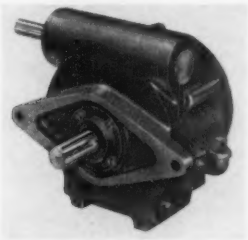
New floating-hub caster is equipped with a light-duty spring to provide shock-absorbing action for lighter loads. The 5½-in. diam wheel caster, which provides shock absorption for loads between 50 and 150 lb per caster, is designed for handling of delicate equipment, electronic instruments, liquids, and other fragile loads. Axle and wheel are supported by a spiral spring which allows hub and wheel to "float" over bumps or depressions. **Bassick Co.**, 3045 Fairfield Ave., Bridgeport 5, Conn. B

Circle 689 on Page 19

Transmission

is rated at 225 lb-ft at 8 rpm output

Model DS combination worm and planetary-gear transmission is rated



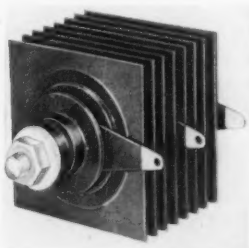
at 225 lb-ft at 8 rpm output. Heat-treated worm is of high-carbon alloy steel. Worm gear is of two-piece construction, with gear portion of bronze alloy. Sun gear is cut from an alloyed grey-iron casting containing chromium and vanadium, and planet gears are heat-treated steel. Ring gear is cut integral with grey-iron housing. Combination provides strength required to withstand extreme pressures of rated torque loads. Unit has a 220:1 ratio, and incorporates a counterclockwise input and output. **Merkle-Korff Gear Co.**, 213 N. Morgan St., Chicago 7, Ill. J

Circle 690 on Page 19

Selenium Rectifier

in cell ratings of 18 to 36 v

New type of selenium rectifier incorporates a polycrystalline selenium layer with grains oriented in parallel rather than disoriented pattern. Design provides increase in current ratings without corresponding increase in cell size. Rectifier is available in cell ratings of 18 to 36 v. **Electric Products Div., Vickers Inc.**, 1815 Locust St., St. Louis, Mo. I



Circle 691 on Page 19

Epoxy Resins

for casting and potting operations

Two new epoxy casting systems have wide industrial application in

ESCO alternator powers new ultra-compact high-performance radar

Based on an entirely new concept in radar design, this Raytheon "Mariners Pathfinder" radar is compact enough for use on the most modest pleasure cruiser, yet big enough in performance for the largest commercial vessels. Utilizing just two, simple units, it provides clear, steady displays up to 16 miles range. Rugged and reliable, it's real sea-going equipment, built to operate in slashing northeasters, arctic ice and the heat and humidity of tropic seas.

To provide a source of dependable, stable power for the "Mariners Pathfinder", Raytheon chose a specially-designed ESCO motor-alternator. Operating from a 32V, 110V or 220V DC ship's supply, this built-to-order inverter delivers a 115V 60-cycle AC output, regulated to ±3V and ±0.6 cycles over a 20% variation in input voltage. It's designed for a minimum of 10,000 hours trouble-free operation under extremely wide variations in temperature, humidity, and pitch and roll conditions.

Building special rotating electrical equipment to meet individual requirements has been a specialty at ESCO for almost half a century. Why not call on ESCO for the ideal generator or motor for your equipment, too? *Write for design brochure today.*

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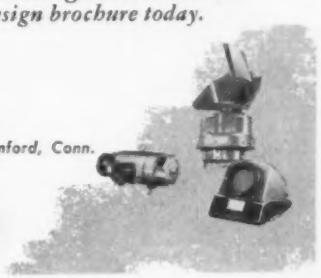

Circle 517 on Page 19

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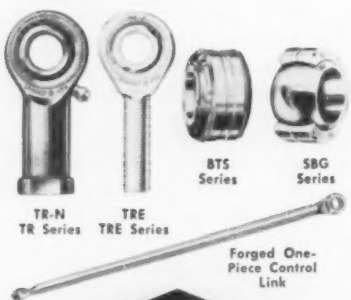

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SPHERCO
A PRODUCT OF
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Circle 518 on Page 19

casting and potting operations. Isocast 405 is an all-purpose filled epoxy casting system suitable for use over a wide range of temperatures. It has excellent adhesion, machine strength, and machinability, and can be used for the encapsulation of heat-sensitive components. Isocast 441 is a two-part, 100 per cent solids epoxy casting compound which is recommended for sealing, potting, and/or encapsulating coils, resistors, capacitors, transformers, and similar electronic components. Properties of the cured 441 material are adjustable from a semirigid, hard casting to a rubbery, flexible sealant by varying operating proportions of the two parts. The 441 material maintains excellent impact resistance and adhesion over broad temperature range. **Isochem Resins Corp.**, 221 Oak St., Providence 9, R. I. B

Circle 692 on Page 19

Forged Needle Valves

for 10,000 psi service

Series 100 general-purpose, forged needle valves are leakproof through the packing from noncritical vacuum to 10,000 psi service. Nylon stem wiper prolongs life of leakproof O-ring stem seal, and prevents foreign matter from scratching or pitting centerless-ground stem, guarding against leakage at high pressures. Operating temperatures range from −40 to 500 F. Typical applications include use on hydraulic lines, air lines, manifolds, test stands, and gaging. **Hoke Inc.**, 111 Tenakil Rd., Cresskill, N. J. D

Circle 693 on Page 19

Clutch-Brakes

in sizes 2, 3, and 5

Style SMCB clutch-brake combinations, furnished as complete units

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Whether you need steel, bronze or stainless-steel to convey air, oil, water, gas, steam, volatiles or light solids, Penflex has the answer. Its complete line of corrugated and interlocked tubing is rugged, safe at high pressures and temperatures. Write for complete data to Pennsylvania Flexible Metallic Tubing Co., Inc., 7239 Powers Lane, Philadelphia 42, Pa.

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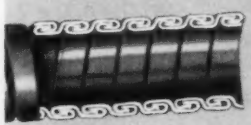
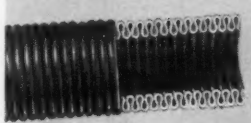


Penflex Interlocked Hose

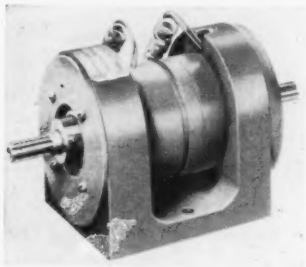


Penflexweld All-Metal Tubing

PENFLEX
TIGHT AS A PIPE BUT...
FLEXIBLE

Circle 519 on Page 19

with bearings, shaft, and mounting stand, are available in sizes 2, 3, and 5. Both clutch and brake are magnetically set, including neutral position. They can be furnished with



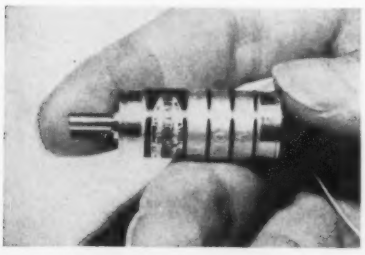
a common armature, splined to driving shaft, or with a common hub with separate armatures for clutch and brake, in order to key hub to shaft, allowing zero backlash. Torque ranges from 25 oz-in. to 175 lb-in. on both clutches and brakes. Clutch and brake coils are set up for dc operation and can be wound for any voltages to 90 v dc. **Stearns Electric Corp.**, 120 N. Broadway, Milwaukee 2, Wis. K

Circle 694 on Page 19

Servo Motor

weighs only 0.85 oz

New 400-cycle servo motor, available in BuOrd size 5, is designated No. 5S1-3. Weighing only 0.85 oz, it operates at 26 v, fixed phase, and 40 v center-tapped control phase, power input of 2 w per phase, and nominal no-load speed of 11,000 rpm. Starting voltage is 0.6 v max, and stall torque is 0.1 oz-in. minimum. Maximum power output is 0.3 w at 6000 rpm, and operating temperature is − 55 to



85 C. With 40-v center-tapped control winding, unit has many possible applications with transistorized amplifiers. **Mechatrol Div., Servomechanisms Inc.**, 1200 Prospect Ave., Westbury, L. I., N. Y. D

Circle 695 on Page 19

For your metals data file . . .

Send for this informative brochure!

Whether your approach to selection and purchasing is "Value Analysis", "Purchasing Research", "Cost Reduction Buying" —or just plain "wise buying", the need for background information on materials is apparent to both designers and purchasing people.

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Circle 520 on Page 19

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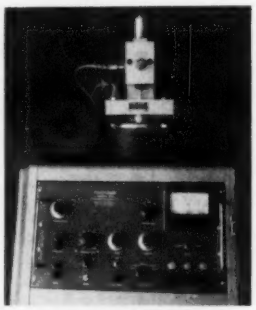
EQUIPMENT

Pneumatic Function Generator

converts electrical signals into pneumatic pressure signals

Functionair Model 100 pneumatic function generator provides a pneumatic signal source for dynamic testing of pneumatic components and systems. It converts electrical signals into pneumatic pressure signals and responds to frequencies from 0 to 50 cps when used with



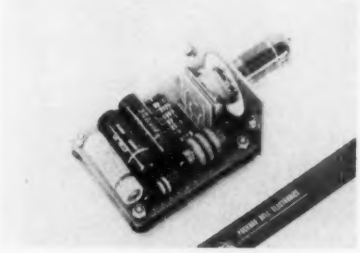
volumetric loads to 20 cu in. Unit can be used to couple analog computer input to control system output. Static accuracy is 1 per cent of full scale, and operating range is from 5 to 300 psia. **Palisades Engineering Co. Inc.**, P. O. Box 22, Pacific Palisades, Calif. L

Circle 696 on Page 19

Audio-Circuit Modules

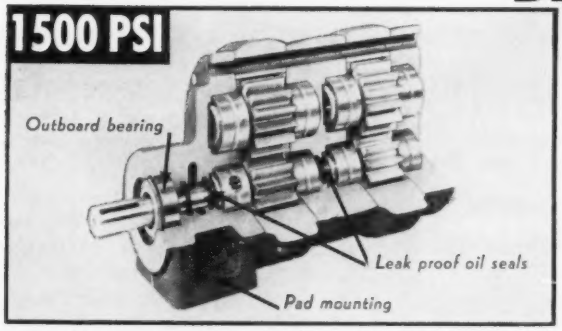
can be combined to build at least 35 circuits

Eleven audio-circuit modules can be used in various combinations to make up common circuits, reducing predesign and breadboarding time. Modules also can be used in pro-



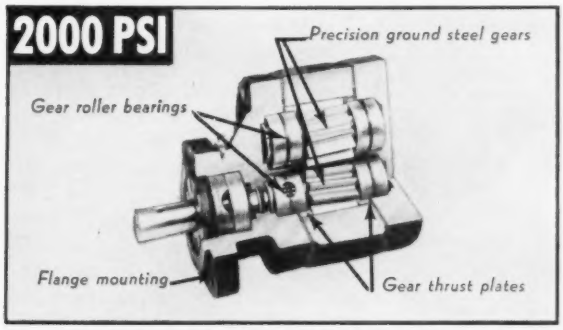
DESIGNER'S CHECK LIST

1500 PSI



Two gear pumps assembled in tandem on common shaft deliver independently—can be piped for dual operation or combined for double capacity single operation. "Pressure Pocketing" reduces slippage, friction and wear—volumetric and mechanical efficiency over 90%.

2000 PSI

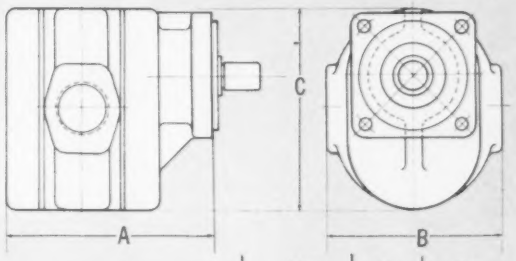


Single gear motor can be piped from side on end ports. Extra large gear bearings maintain shaft alignment; heavy-duty outboard bearing absorbs drive shaft and shock loadings. New leakproof oil seals maintain internal pressure balance.

PUMPS — — — DEVELOP OIL HYDRAULIC POWER
1500 PSI—2 to 100 gpm—continuous duty operation
2000 PSI—12 to 36 gpm—continuous duty operation

MOTORS — — UTILIZE OIL HYDRAULIC POWER
1500 PSI — 2 to 68 hp—continuous duty operation
2000 PSI —12 to 36 hp—continuous duty operation

DIMENSIONAL DATA (Approx.)



		A*	B	C
1500 PSI	C SERIES	4″ + gw	4″	4½″
	D SERIES	5¼″+ gw	6½″	6¾″
	J SERIES	7″ + gw	8″	9″
2000 PSI	36H SERIES	6½″+ gw	6½″	7⅛″

*When fitted with socket head cap screws. If fitted with hex head cap screws add thickness of head. gw = gear width

Actual performance data for pumps and motors having gear width other than one inch can be computed by multiplying values in following tables by desired gear width.

1500 PSI PUMPS

	AVAILABLE GEAR WIDTHS	SPEED (RPM)	OUTPUT PER INCH OF GEAR WIDTH (gpm at discharge pressure psi) 500	1000	1500	INPUT PER INCH OF GEAR WIDTH (hp at discharge pressure psi) 500	1000	1500
C SERIES	½″, 1″, 1½″	600	2.3	1.1	0.5	1.2	2.3	3.5
		1200	4.5	3.6	2.6	2.4	4.5	7.0
		1800	7.2	6.0	5.5	3.8	6.7	10.5
D SERIES	½″, ¾″, 1″, 1½″, 2″, 2½″, 3″	600	6.6	6.4	6.3	2.6	4.0	7.0
		1200	13.2	13.0	13.0	5.2	8.0	13.5
		1800	19.3	19.0	19.0	7.5	12.0	20.5
J SERIES	2″, 2½″, 3″, 3½″, 4″	600	9.7	9.3	9.2	3.1	6.1	9.0
		1200	20.6	20.3	20.0	6.4	12.3	18.7
		1800	31.0	30.5	30.1	10.2	19.3	29.4

1500 PSI MOTORS

	SPEED (RPM)	INPUT PER INCH OF GEAR WIDTH (gpm at input pressure psi) 600	1000	1500	OUTPUT PER INCH OF GEAR WIDTH (hp at input pressure psi) 600	1000	1500
C SERIES	600	4.1	4.7	5.3	0.8	1.4	2.4
	1000	7.1	7.4	7.7	1.3	2.4	3.4
	1500	9.6	10.4	10.8	1.9	3.5	4.5
D SERIES	600	8.2	8.6	9.0	2.1	3.5	4.3
	1000	12.5	13.6	14.0	3.5	5.8	8.0
	1500	18.0	19.0	20.0	4.3	8.0	11.2
J SERIES	600	10.6	10.9	11.6	2.8	5.1	7.7
	1000	17.1	17.7	18.4	4.3	7.9	12.4
	1500	27.0	27.5	28.7	5.1	10.7	17.1

2000 PSI PUMPS

	AVAILABLE GEAR WIDTHS	SPEED (RPM)	OUTPUT PER INCH OF GEAR WIDTH (gpm at discharge pressure psi) 1000	1500	2000	INPUT PER INCH OF GEAR WIDTH (hp at discharge pressure psi) 1000	1500	2000
36H SERIES	1″, 1½″, 2″, 2½″, 3″	600	4.7	4.5	3.9	4.7	7.4	8.8
		1200	12.3	12.1	11.7	9.5	14.2	19.8
		1800	20.0	19.3	18.9	14.8	21.4	29.3

2000 PSI MOTORS

	SPEED (RPM)	INPUT PER INCH OF GEAR WIDTH (gpm at input pressure psi) 800	1200	2000	OUTPUT PER INCH OF GEAR WIDTH (hp at input pressure psi) 800	1200	2000
36H SERIES	600	6.9	7.3	8.0	2.3	3.7	6.2
	1000	11.2	11.7	12.7	3.3	5.6	10.2
	1600	*	18.9	20.1	*	6.8	14.2

* not recommended for 1″ or 2″ gears at 1600 rpm

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COMMERCIAL shearing & stamping

Circle 522 on Page 19

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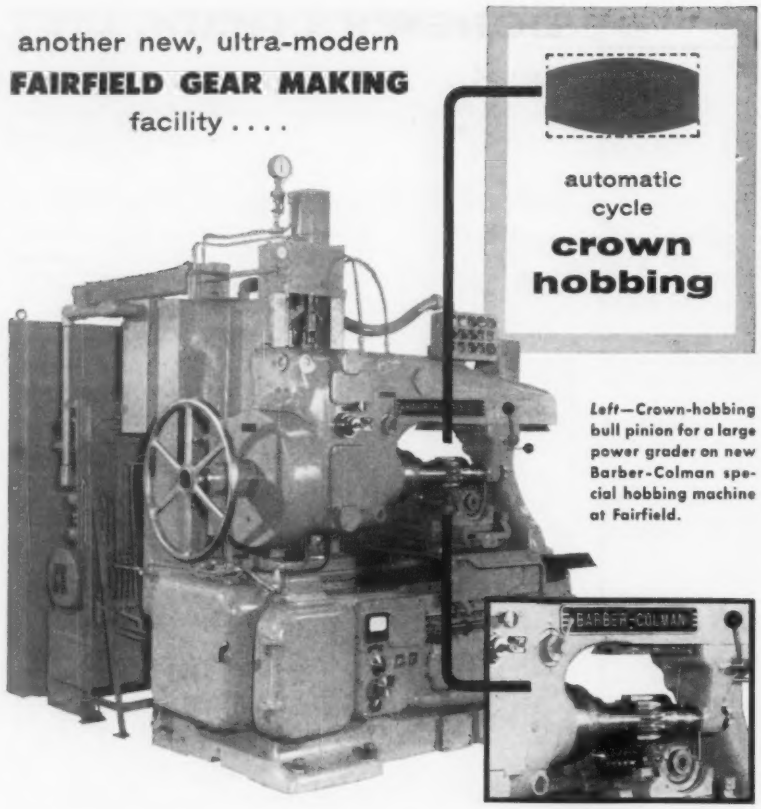
FAIRFIELD GEAR MAKING
facility . . . .



Left—Crown-hobbing bull pinion for a large power grader on new Barber-Colman special hobbing machine at Fairfield.

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You get every benefit of latest cost-cutting methods and equipment when your gears are produced by Fairfield. "Automatic Cycle Crown Hobbing" is one interesting example of a new method for generating *accurately* crowned teeth on spur gears and pinions. In addition to significant time savings produced by a remarkably versatile machine, subsequent finishing costs can be reduced, or may be completely eliminated. Special tooth strength characteristics may also be obtained economically.

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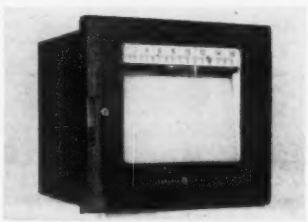
duction of electronic equipment. Unit shown is a two-stage equalized audio amplifier. Modules can be combined to build at least 35 complete circuits including tape recorder, broadcast preamplifier, broadcast line amplifier, tape-playback amplifier, public address system, control amplifiers, and modulators. **Technical Products Div., Packard-Bell Electronics Corp.,** 12333 W. Olympic Blvd., Los Angeles 64, Calif. L

Circle 697 on Page 19

Recorder-Controller

is null-balance strip-chart unit

New null-balance strip-chart recorder-controller is available in a dc potentiometer, ac or dc bridge version, in both single-pen and multirecord types. It has a 10¾-in. calibrated chart width. Applications include use in electric utilities, measurement and recording of pH, conductivity, temperature, flow, and pressure in the atomic, petrochemical, and metal industries, and in research and testing facilities. Continuous automatic standardization is achieved by means of a silicon diode reference which provides continuous measurement and control at all times. Printed circuits and plug-in components are used throughout the instrument. Major components are mounted on rear of mechanism panel which swings out through a 160-deg arc. **Instrument Dept., General Electric Co.,** West Lynn, Mass. B



Circle 698 on Page 19

Power Pack

provides 1 amp ac and dc control

New Lab-Pack provides both ac and dc variable control in a 100-w device. Unit operates from a 110-v 60-cycle outlet and provides ouput

Circle 523 on Page 19

control from 0 to 130 v ac or from 0 to 125 v dc. Full-wave bridge rectifier provides direct current.

Unit is rated at 1 amp for both ac and dc. Pilot-light indicator, on-off switch, and test leads are provided. **Electrol Specialties Co.**, South Beloit, Ill. K

Circle 699 on Page 19

Drafting Tables

combine drafting surface, desk, and files

New Stacor-Matic single-unit work stations combine in one unit a drafting surface for one man and desk

and file space for the man in front of him. Units have automatically adjustable board height and slope, built-in electrical outlets, pull-out linoleum desk top, and three all-steel drawers for reference material. Series includes standard, front, and rear units in a range of base and board sizes. **Stacor Equipment Co.**, 295 Emmet St., Newark 5, N. J. D

Circle 700 on Page 19

Whiteprinting Machines

have speeds to 75 fpm

Revolute Star automatic whiteprinting machines have either 100 or 150-w lamps and speeds to 75 fpm. Revised cooling system assures lower cylinder temperatures and improved performance of tracing and print-handling systems. Other features include separate feeding belts, adjustable tracing tray, electronic drive, and air-knife pickoff. **Paragon-Revolute Corp.**, 77 South Ave., Rochester 4, N. Y. N

Circle 701 on Page 19

QUALITY BALLPOINT PEN DEPENDS ON UNIFORMITY OF 8 GRC "MATED" PARTS

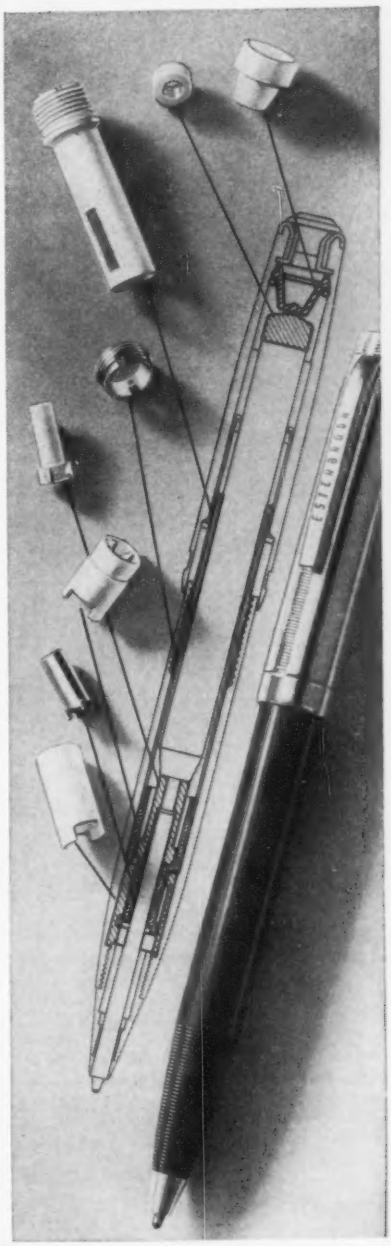
Die Cast and Molded Components Assure Trouble-free Operation of Esterbrook's New Rotating Mechanism

GRC mass-production techniques have again provided a new dimension to designers faced with a difficult situation. Esterbrook engineers, realizing that most people pick up a pen repeatedly the same way, evolved a rotating mechanism to avoid wearing the ballpoint unevenly and to achieve better ink distribution. The intricate mechanism, however, presented a production problem. Parts had to be uniform, durable, meet close tolerances in order to assure proper mating of components and dependable functioning of the assembled pen.

GRC's exclusive patented methods for the precise automatic production of tiny parts solved the problem, and at lower costs. Gries molded five of the parts in duPont nylon, die cast two others in zinc alloy for strength and greatest economy. The eighth was Gries nylon counterpart for an originally-scheduled screw machine part, produced for a fraction of the cost and more satisfactorily. These eight parts form the foundation of the mechanism for this new-type pen.

Uniformly accurate, clean, well within critical tolerances, these GRC die cast and molded parts eliminated the necessity of selective assembly and insure trouble-free operation by fitting mating parts exactly. Tests of the pen showed parts worked like new after the equivalent of more than a year's normal use, still worked smoothly after the equivalent of fifty years' hard use. (See illustration at left above.)

This high quality pen is typical of the new designs and cost saving economies possible through Gries' unique single cavity molding techniques and ingenious die casting methods. To find out how GRC can help you, write for their bulletins on tiny zinc alloy die castings and injection molded small plastic parts, or send prints for immediate quotations. There is no minimum size. Maximums are 1¾" long, ½ oz. in zinc alloy; 1¼" long, .03 oz. in plastic.



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GRIES

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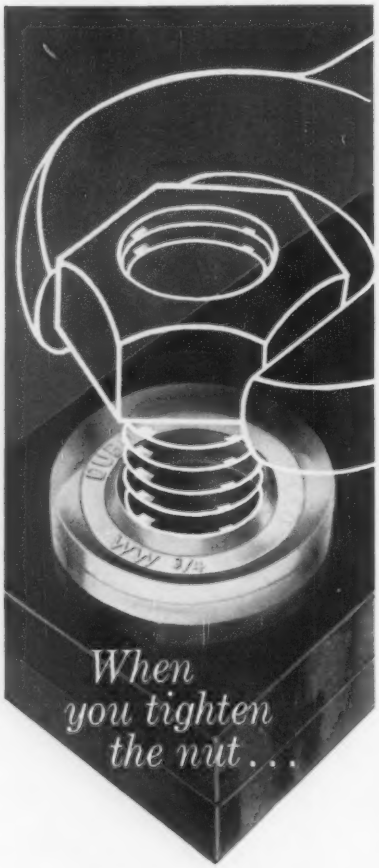
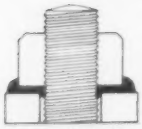
Circle 524 on Page 19

This new lock and seal washer is just plain **REVOLUTIONARY...**



NYLOGRIP Dubo Lockwasher locks and seals it-instantly!



Patents Applied For

The new NYLOGRIP Dubo Lockwasher is made of a special, cold-flow plastic called Nylon 6. When the nut is tightened, the washer "flows" — its inner diameter grips into the threads of the nut and bolt, to seal this junction against leakage, while the outer diameter flows over the outer edges of the nut, seals and locks it . . . so tight neither shock nor vibration can budge it! The Dubo Lockwasher can be used time and again without the slightest loss of holding power. And, because it's symmetrical and has no threaded parts, you couldn't fit one incorrectly if you tried.

PLUS FEATURES: excellent electrical properties . . . exceptional wear resistance . . . good shock absorption . . . resists corrosion, chemicals . . . non-flammable . . . high flexural strength.

PLUS USES: The excellent electrical characteristics of NYLOGRIP Dubo Lockwashers make them ideal for electrical insulation, or to help control electrolytic corrosion between dissimilar metals.

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Non Metallic Fastenings of all types.

Circle 525 on Page 19

THE ENGINEER'S Library

Recent Books

Handbook of Calculus, Difference and Differential Equations. *By Edward J. Cogan, department of mathematics, Sarah Lawrence College and Robert Z. Norman, department of mathematics, Dartmouth College; 263 pages, 6 by 9 in., clothbound; published by Prentice-Hall Inc., 70 Fifth Ave., New York 11, N. Y.; available from* MACHINE DESIGN, *$6.00 per copy postpaid.*

This handbook presents a review of the function properties used in calculus and differential equations, as well as tables of values for common transcendental functions, and a table of integrals.

Also included in this book are tables for the solution of differential equations along with discussion on how to use them.

Trouble-Free Hydraulics. *By Ian McNeil; 124 pages, 5½ by 8¼ in., clothbound; published by the Ronald Press Co., 15 East 26th St., New York 10, N. Y.; available from* MACHINE DESIGN, *$6.50 per copy postpaid.*

This manual is a step-by-step guide to operation of hydraulic machinery and what to do when trouble develops. Although written primarily for maintenance engineers, considerable information is included on the application of hydraulic power to machine operation.

As a reference source, the book contains tables and charts on topics such as characteristics of hydraulic leathers, characteristics of rubber and synthetic rubber seals, allowable working pressure for seals, tensile properties of pipe metals, and spring-loading of packings.

How to Become a Professional Engineer. *By John Constance; 272 pages, 5⅜ by 8 in., clothbound; published by McGraw-Hill Book Co., Inc., 330 West 42nd St., New York 36, N. Y.; available from* MACHINE DESIGN, *$5.50 per copy postpaid.*

This is a comprehensive guide for both unlicensed engineers-in-practice and young graduates on

keep hydraulic valves free and functioning properly . . . . .

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MAGNETIC SEPARATORS

Shown is high pressure model P2H50 for service to 5000 psi. Other models for low pressure rated at 100 psi.

And Here's How It's Done

Fluid passes through a stack of grids (lower right) magnetized by two powerful Alnico magnets (upper right, lower left). The "honeycomb" design of the grids splits the flow into thin streams, allowing fine particles of iron, rust and scale to be caught and held on the grid edges.

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Circle 526 on Page 19

how to obtain a professional engineer's license. Among the subjects discussed are the basic requirements for licensure, summaries of the various state registration laws, and examples of how examining boards evaluate the experience of candidates.

The book explains how to prepare an application, gives pointers on selecting the qualifying experience and writing it up, shows how to prepare for written and oral examinations, points out what to look for in refresher courses, and tells how to achieve multiple-state registration.

New Standards

Expansion Joint Standards. *31 pages, 8½ by 11 in., paperbound and side stapled; published by and available from the Expansion Joint Manufacturers Association, 53 Park Place, New York City, N. Y.; $1.00 per copy.*

This standard contains information on the design, construction, application, and testing of expansion joints for piping and other services.

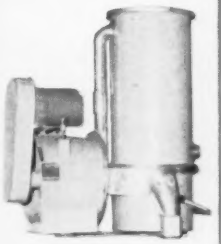
Government Publications

Thermal Properties of High Temperature Materials, PB 131718. *By I. B. Fieldhouse, J. C. Hedge, J. I. Lang and T. E. Waterman of Armour Research Foundation; 79 pages, 8½ by 11 in., paperbound; published by and available from Office of Technical Services, U. S. Dept. of Commerce, Washington 25, D. C.; $2.25 per copy.*

This report gives the thermal properties of eight high-temperature materials. Properties covered include thermal conductivity, specific heat, and linear-thermal expansion.

Materials-Property-Design Criteria for Metals—Part IV, PB 131515. *By W. P. Achback, R. J. Favor, and W. S. Hyler; 245 pages, 8½ by 11 in., paperbound; prepared by Wright Air Development Center; available from Office of Technical Services, U. S. Dept. of Commerce, Washington 25, D. C.; $6.00 per copy.*

This report contains a compilation of data on the conventional short-time elevated-temperature properties of selected aluminum, magnesium, and titanium alloys. A summary of technical data and a description of each alloy are also presented.



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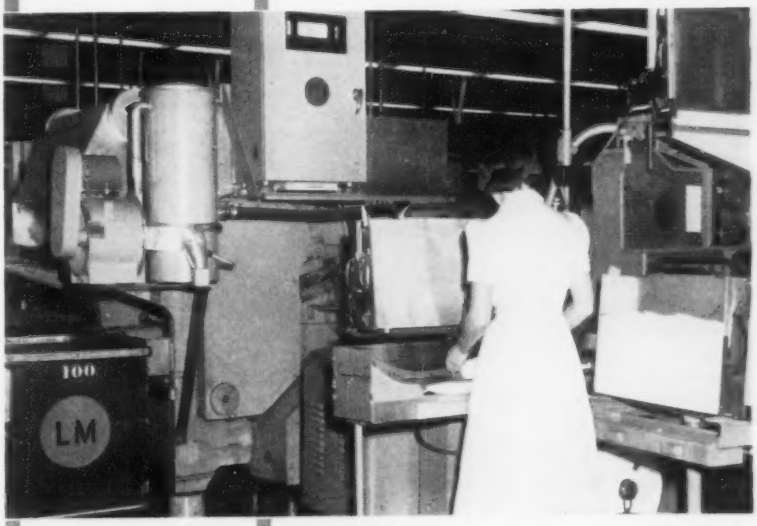
DESIGN PROBLEM

solved . . . with a SPENCER vacuum unit



Two Catalogs to Aid the Designer

"132 UNUSUAL USES OF SPENCER VACUUM"
Bulletin 144 illustrates and describes how Spencer Vacuum is used in industries from A to Z.

"TURBO DATA BOOK"
Supplies application data on Spencer Blowers. Request Bulletin 107-C.

The designer's problem here was: find a means of picking up the "shorts"—short pieces of tobacco which hang loosely on the end of a cigarette before the filter tip is applied.

Incorporation of a SPENCER vacuum unit, connected adjacent to the main cigarette drum, proved the answer.

Perhaps vacuum can solve *your* design problem. Why not check with SPENCER, producers of a complete line of vacuum units—standard or specially adapted to meet your particular needs.

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Up to 12" Mercury Vacuum
Volumes up to 17,000 C.F.M.

SPENCER

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Circle 527 on Page 19

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VALUE UP—

ON CRESCENT® VALVES

- **Same High Quality**
- **Same Proven Design**
- **a Better Coil Added**

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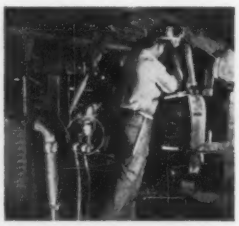
and Tested for
Over 100 Million Cycles

Value is up because all standard Crescent Solenoid valves will be equipped with improved water-proof coils with a 25 million cycle life expectancy (test units have been subjected to continuous operation of over 100 million cycles without being touched).

Proof:
High flow capacity
. . . to operate the jaws of a giant.



Proof:
A fast life and a long one
. . . in auto plants.

In every respect Crescent valves have retained their high quality construction, materials and, most important, their design, proven by years of reliable service; this is not a cheapened valve of unproved operation quality, looking for guinea pigs.

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. . . in cement batching plants.

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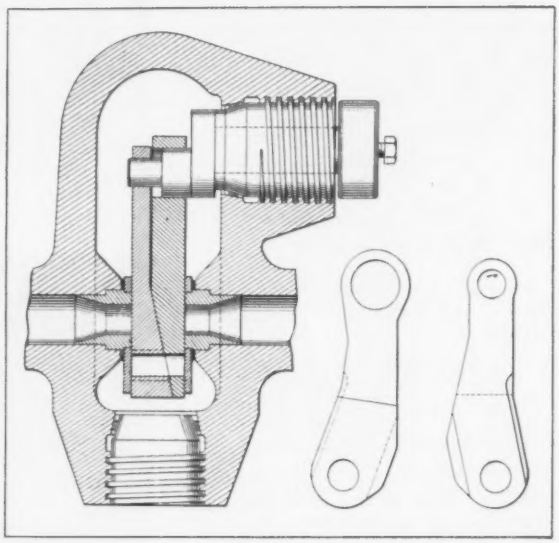
5125 ALCOA AVENUE • LOS ANGELES 58 • CALIFORNIA

NOTEWORTHY

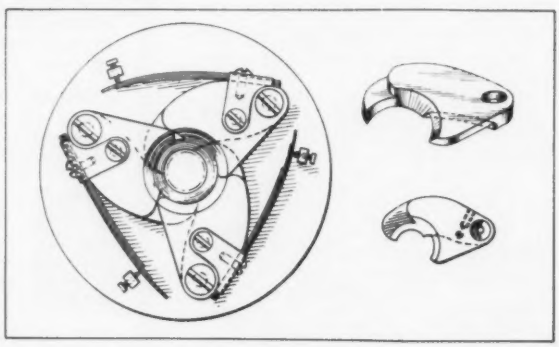
Patents

High-Pressure Valve



Straight-line flow through a high-pressure valve is assured by a two-plate gate. Simultaneously, the plates are moved and positioned, like connecting rods, by studs integral with the operating handle shaft but eccentric to its axis. In the open valve position, holes in both plates are aligned with the main valve passage. In the closed position, both plates block the passage and are wedged together, between the valve seats, by their own inclined surfaces. *Patent* 2,836,390 *assigned to ACF Industries Inc., by Charles R. Shumate.*

Flexible Orifice



Mounted in a barrier between zones of different fluid pressures, an orifice minimizes loss of fluid and pressure across the barrier as it guides coated wire or tubing which moves continuously through the zones. Sectors of the orifice flex to pass lumps in escaping fluid

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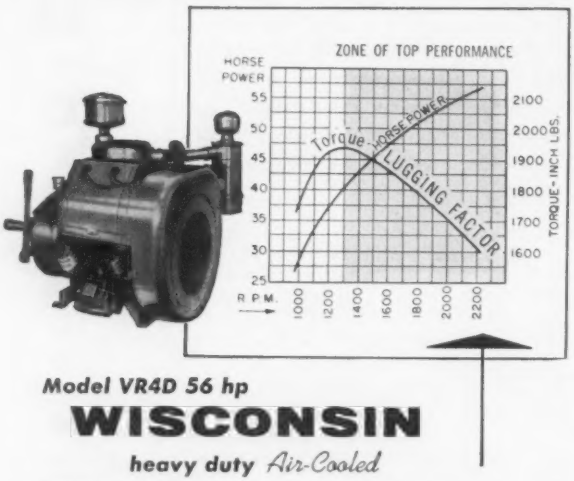


Model VR4D 56 hp

WISCONSIN

heavy duty *Air-Cooled*

ENGINE *POWER CURVE*

When the power load suddenly *builds up* and the engine speed *slows down* . . . how long will the engine *hang on* and carry the increased load without stalling?

The answer lies in the HIGH TORQUE LUGGING FACTOR which is an integral part of "Wisconsin" basic engineering. The point at which an engine will stall under suddenly increased loads is the *High Point* in the TORQUE CURVE. As a case in point, analyze the Wisconsin Model VR4D power curves reproduced here.

This engine develops its maximum horsepower (56 hp.) at 2200 rpm. at which point it registers a torque of 1600 inch-lbs. The engine runs into heavy going. The load builds up fast. The rpm. slows down to 2000, 1800, 1600 and 1400 rpm., reaching its maximum torque *at the low speed* of 1300 rpm.

In terms of power service to the user, this simply means that your Wisconsin Engine is designed *to provide dependable load-holding power at low engine speeds.* This, in turn, means fewer shutdowns, less wear and tear, more usable power and more versatile performance for your dollar investment.

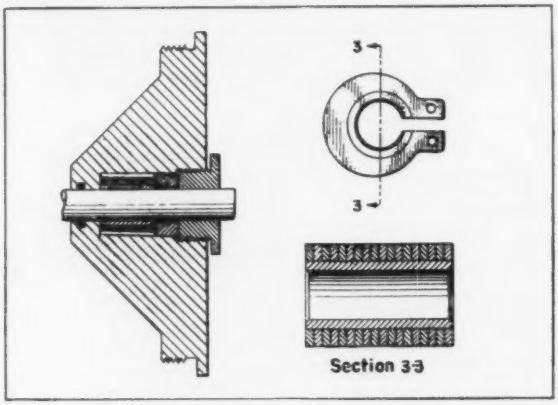
These are reasons why it pays to specify "Wisconsin Power" for your equipment. For a briefing on the full line, write for Engine Bulletin S-223.

A8-6218-½A

Circle 530 on Page 19

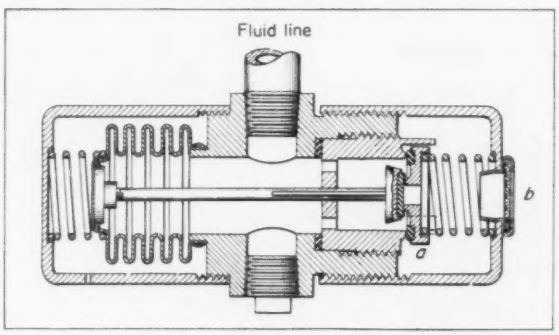
and irregularities in the wire or tube coating. Three identical parts comprise the orifice. Each overlaps both the others along bevelled lengths of their contours which form the orifice. To pass irregularities, each pivots individually against the force of an adjustable leaf spring. *Patent* 2,847,036 *assigned to Northern Electric Co., Montreal, Quebec, Canada, by Thomas D. A. Dow.*

Adjustable Friction Sleeve



The total force with which a split sleeve grips a shaft can be changed by adding or removing grip rings on the sleeve OD. The force can also be changed by using rings of different size, thickness, or physical characteristics. To prevent turning of the sleeve in a larger assembly, lugs on the rings are received in a "keyway" of an adjacent housing. *Patent* 2,844,223 *assigned to The Goodyear Tire & Rubber Co., Akron, Ohio, by John W. Runner.*

Precision-Action Relief Valve



Use of a metallic bellows in a combined pressure-vacuum relief valve enables the valve to open much closer to both high and low settings than do valves which function solely by pressure against flat plates. Inherently high sensitivity, due to the extensive operating surface of the bellows, also prevents flutter at pressures near the relief settings. The valve plug, *a*, permits high-pressure flow outward and low-pressure flow inward through filter *b*. Pressure limits are set by turning the threaded cover cups. *Patent* 2,844,165 *assigned to General Electric Co. by Francis Morse.*

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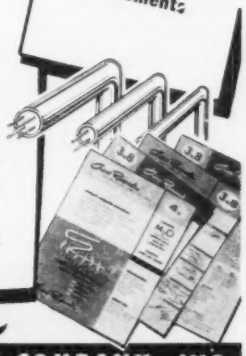

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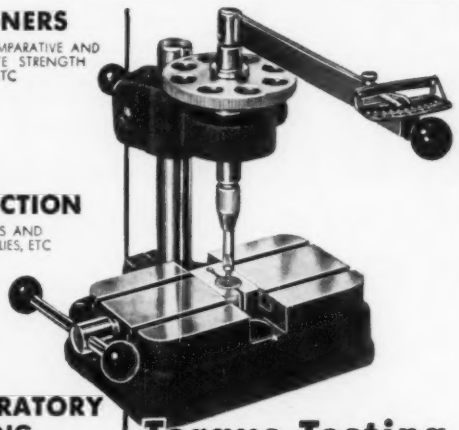

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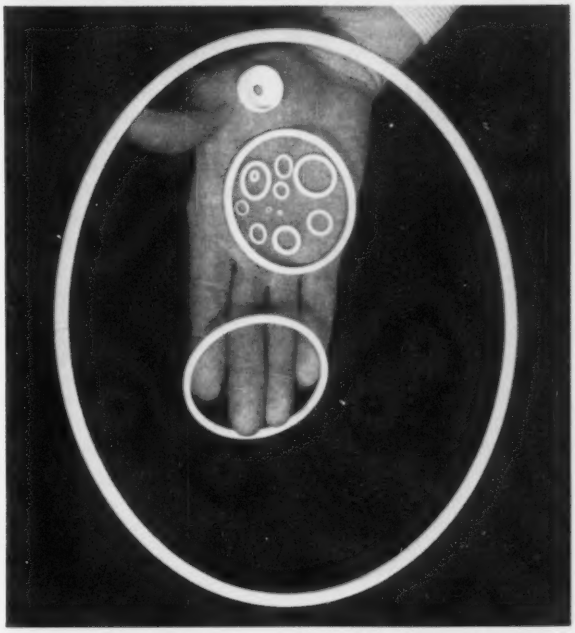

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Torque motors deliver maximum rated torque without damage to the windings when stalled across the line at full voltage for predetermined periods. Peerless also builds torque motors which provide a nearly constant torque while operating at less than synchronous speeds.

All standard frame sizes; all types of mountings; high torques; special paint and varnish treatments; and Class A, B and H insulation are available from Peerless. Torque motors require unusually close cooperation between the motor supplier and the customer's engineers. This cooperation is a Peerless specialty. We will work with you to produce the one torque motor that powers your product best.

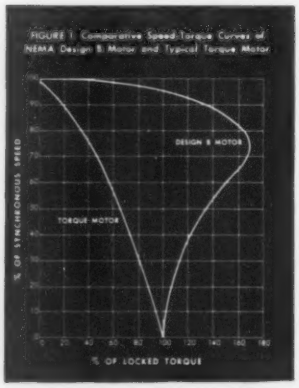
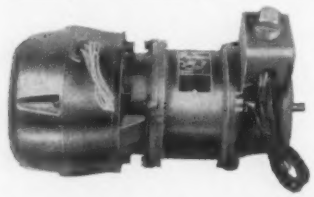
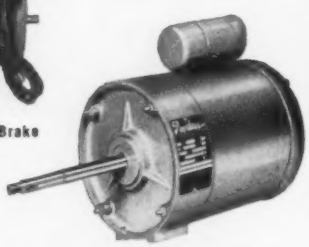


FIGURE 1. Comparative Speed-Torque Curves of NEMA Design B Motor and Typical Torque Motor
% OF SYNCHRONOUS SPEED
DESIGN B MOTOR
TORQUE MOTOR
% OF LOCKED TORQUE

The speed-torque curve varies from that of a conventional motor. The torque motor curve is almost linear. Maximum torque occurs at the stalled position. For this reason, torque motors are used most often where a holding or resisting force is required.



Explosion-Proof Torque Motor With Brake



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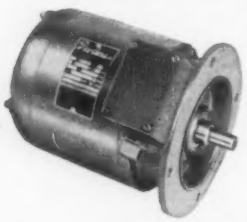

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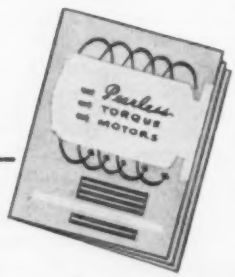

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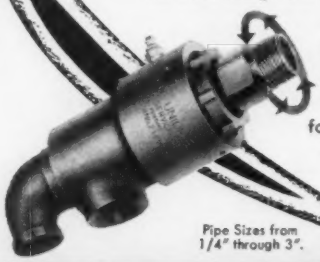

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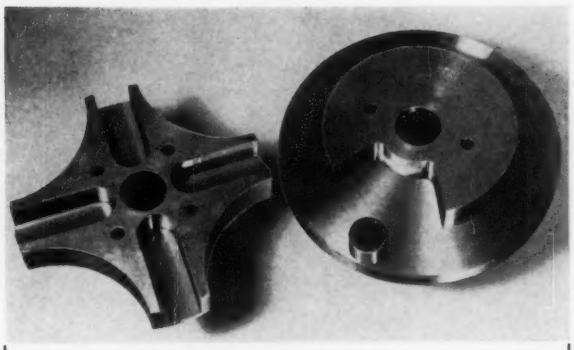

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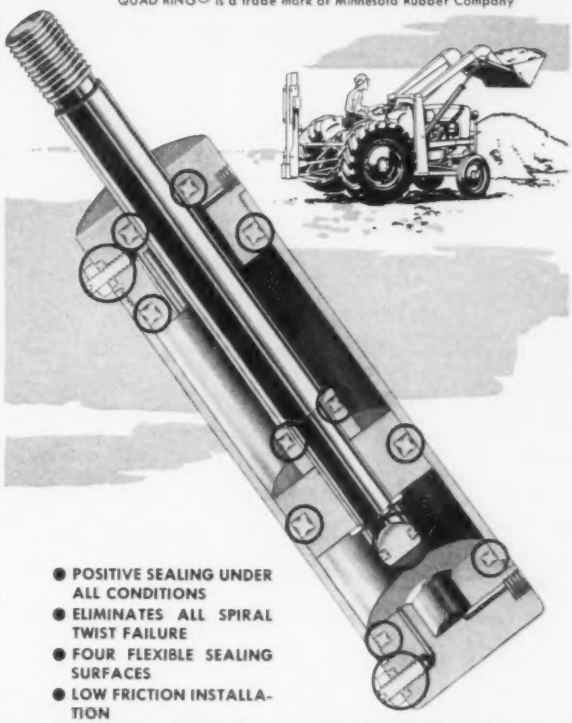

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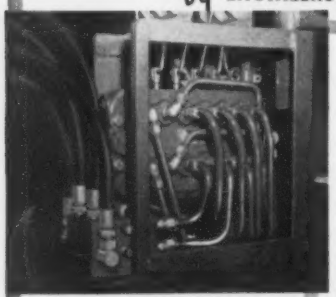

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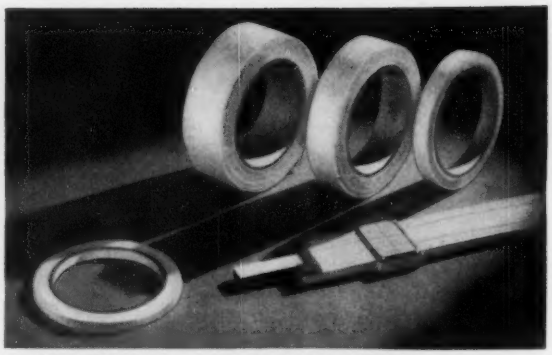

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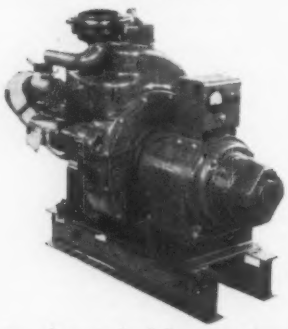

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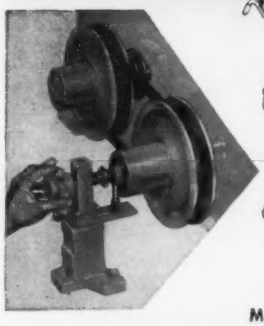

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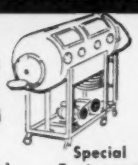
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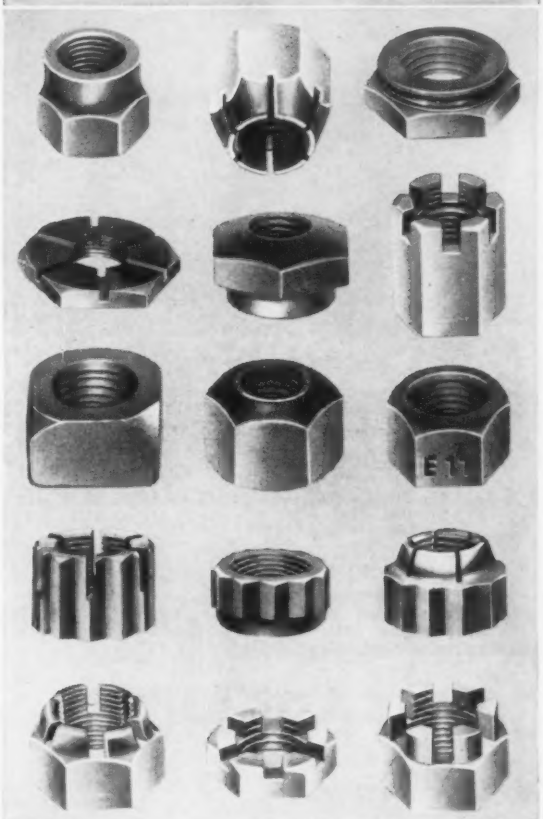

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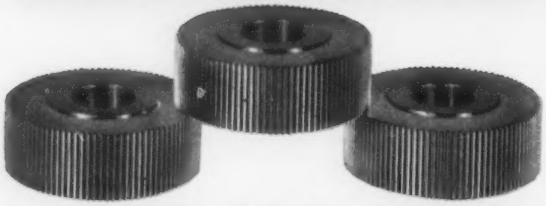

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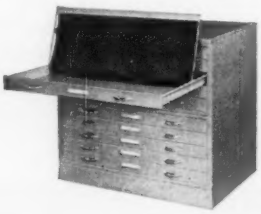

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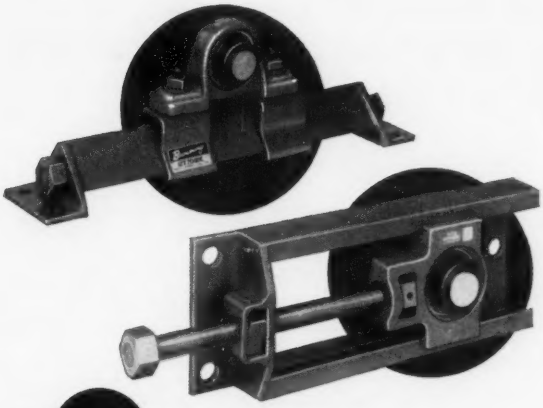

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Browning POWER TRANSMISSION EQUIPMENT

Circle 549 on Page 19

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WRITE FOR NEW CATALOG

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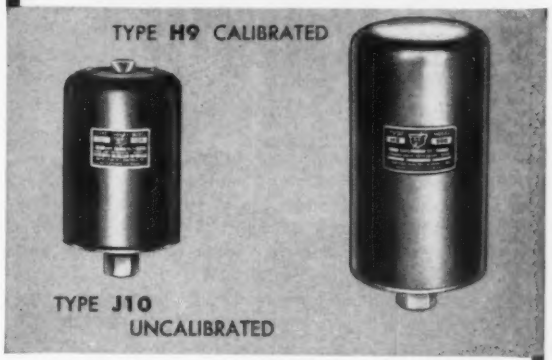
Circle 550 on Page 19

Sensitive H9 J10

PRESSURE and VACUUM CONTROLS



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United Electric Controls COMPANY

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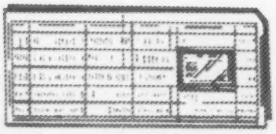
Circle 551 on Page 19



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Circle 552 on Page 19

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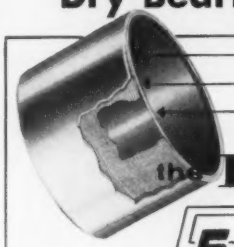
USE THE YELLOW CARD ON PAGE 19.

a New, ADVANCED Dry Bearing Construction



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This new construction makes it possible to run bearings at

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Circle 553 on Page 19

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Advertising Index

Aero Research Instrument Co., Inc. 189
Aluminum Company of America 53
American Blower Division, American-Standard 76, 77
American Brake Shoe Co., American Manganese Steel Division 90
American Manganese Steel Division, American Brake Shoe Co. 90
American-Standard, American Blower Division 76, 77
American Steel & Wire Division, United States Steel Corporation 56, 57
Armstrong Cork Co., Industrial Division 146
Arrow-Hart & Hegeman Electric Co., The 40, 41

Babcock & Wilcox Co., The, Tubular Products Division 5
Barco Manufacturing Co. 176
Barksdale Valves 186
Beaver Precision Products, Inc. 149
Bethlehem Steel Co. 95
Bodine Electric Co. 1
Bower Roller Bearing Division, Federal-Mogul-Bower Bearings, Inc. 31
Browning Manufacturing Co. 195

Carter Controls Inc. 39
Chicago Rawhide Manufacturing Co. 2
Colorado Fuel and Iron Corporation, The 71
Columbia-Geneva Steel Division, United States Steel Corporation 56, 57
Commercial Shearing & Stamping Co. 181
Connecticut Hard Rubber Co., The 192
Continental Screw Co. 64
Copperweld Steel Co., Aristoloy Steel Division 11
Crane Packing Co. 157
Crucible Steel Company of America, Spring Division 93
Cutler-Hammer, Inc. 7

DeLaval Steam Turbine Co. 51
Diamond Chain Co., Inc. 91
Dixon Corporation, Plastics Division 196
Drop Forging Association 143
Duff-Norton Co., Coffing Hoist Division 173
du Pont, E. I., de Nemours & Co., Inc. 52, 61, 89
Durakool, Inc. 158
Dynamatic Division, Eaton Manufacturing Co. 75

Eagle-Picher Co., The, The Ohio Rubber Co. Division 72
Eastman Kodak Co. 147
Eastman Manufacturing Co. 192
Eaton Manufacturing Co., Dynamatic Division 75
Electric Specialty Co. 177
Elgin Metalformers Corporation 37
Equipment Sales Division, Raybestos-Manhattan, Inc. 45, 46, 47
Ex-Cell-O Corporation, Rotac Division 65

Fafnir Bearing Co., The 67
Fairfield Manufacturing Co. 182
Federal-Mogul-Bower Bearings, Inc., Bower Roller Bearing Division 31
Federal-Mogul-Bower Bearings, Inc., National Seal Division 148
Ferguson Machine Corporation 38
Filmsort Co., The 196
Frantz, S G., Co., Inc. 184

Garlock Packing Co., The 151
Gates Rubber Co., The 82
General Aniline & Film Corporation, Ozalid Division 35
General Electric Co., Metallurgical Products Division 50
Genevamatic Engineering Corporation 191

Gleason Works 9
Goodrich, B. F., Co., The, Aviation Products Division 49
Goodrich Chemical, B. F., Co., Division of The B. F. Goodrich Co. 86
Gould-National Batteries, Inc., Nicad Division 169
Gray Iron Founders' Society Inc. 150
Gries Reproducer Corporation 183

Haloid Xerox, Inc. 73
Han-Dee Spring & Manufacturing Co., The 191
Harrington & King Perforating Co., Inc., The 158
Hart Manufacturing Co., The 166
Haynes Stellite Co., Division of Union Carbide Corporation 80, 81
Hoover Ball and Bearing Co. 55

Industrial Tectonics, Inc. 34
International Nickel Co., Inc., The 85
Invo Spline, Inc. 194
I-T-E Circuit Breaker Co., Transformer & Rectifier Division 48

Jeffrey Manufacturing Co., The 94

Kaydon Engineering Corporation, The 21
Keuffel & Esser Co. 59

Laclede Steel Co. 36
Lamb Electric Co., The 58
Lewellen Manufacturing Co. 15
LimiTorque Corporation 166
Link-Belt Co. 33
Lister-Blackstone, Inc. 192
Lovejoy Flexible Coupling Co. 174
Lynair, Inc. 195

McGill Manufacturing Co., Inc. 138

Madison-Kipp Corporation 156
Manhattan Rubber Division, Raybestos-Manhattan, Inc. 45, 46, 47
Mahon, R. C., Co., The 83
Malleable Founders' Society 179
Master Electric Co., The, Division of Reliance Electric and Engineering Co. ..... Inside Back Cover
Mayline Co. 194
Metallurgical Products Department of General Electric Co. 50
Metals & Controls Corporation, Spencer Division 60
Minnesota Mining and Manufacturing Co., Adhesives, Coatings and Sealers Division 79
Minnesota Rubber Co. 191
MPB, Inc., Split Ballbearing Division 171
Mt. Vernon Die Casting Corp. 144
Muskegon Piston Ring Co., Rotary Seal Division 16

National Machine Products Co. 193
National Malleable and Steel Castings Co. 87
National Seal Division, Federal-Mogul-Bower Bearings, Inc. 148
National Supply Co., The 198
National Tube Division, United States Steel Corporation 56, 57
National Vulcanized Fibre Co. 159
New Hampshire Ball Bearings, Inc. 153
Nicad Division, Gould-National Batteries, Inc. 169
Norgren, C. A., Co. 42, 43
Norma-Hoffmann Bearings Corporation ..... Inside Front Cover
Nosco Plastics, Inc. 162
Nylogrip Products 184

Ohio Rubber Co., The, A Division of The Eagle-Picher Co. 72
Ozalid, A Division of General Aniline & Film Corporation 35

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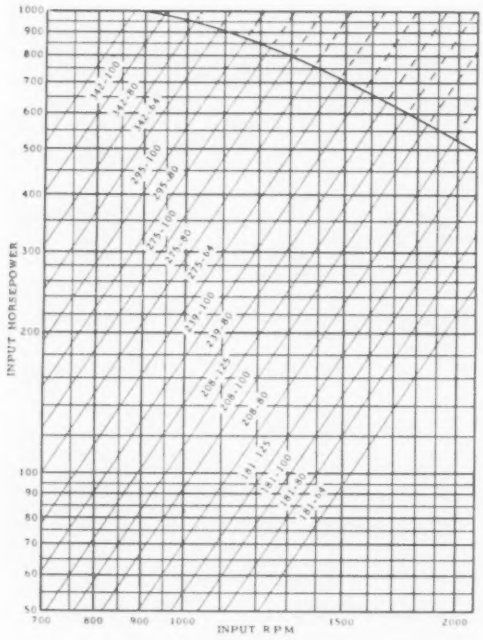

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Pace-setters in the progress of industrial power transmission

Advertising Index

Packing Division, Raybestos-Manhattan, Inc. 45, 46, 47
Peerless Electric Co., The, Electric Motor Division 190
Pennsylvania Flexible Metallic Tubing Co., Inc. 178
Perfecting Service Co. 190
Perkins Machine and Gear Co. 163
Philadelphia Gear Corporation 166
Potter & Brumfield, Inc. 155
Precision Rubber Products Corporation 165
Process Gear Co. 193

Raybestos-Manhattan, Inc. 45, 46, 47
Reliance Electric and Engineering Co., The Master Electric Co. Division ..Inside Back Cover
Reuland Electric Co. 92
Robbins & Myers, Inc. 62, 63
Robertshaw-Fulton Controls Co., Flexible Shaft Division 164
Roll Formed Products Co. 167
Rollway Bearing Co. 161
Roper Hydraulics, Inc. 152
Rotac Division, Ex-Cell-O Corporation 65
Rotary Seal Division, Muskegon Piston Ring Co. 16
Russell, Burdsall & Ward Bolt and Nut Co. .. 66

Sigmamotor, Inc. 190
SKF Industries, Inc. 44
Somers Brass Co., Inc. 172
South Chester Corporation, Southco Division .. 88
Southco Division, South Chester Corporation .. 88
Southwest Products Co. 193
S-P Manufacturing Corporation, The 145
Speed Selector, Inc. 192
Spencer Division, Metals & Controls Corporation 60
Spencer Turbine Co., The 185
Spherco, Sealmaster Bearing Division, Stephens-Adamson Mfg. Co. 178
Split Ballbearing, A Division of MPB, Inc. .. 171
Standard Pressed Steel Co. 54
Stanpat Co. 172
Statham Instruments, Inc. 174
Stephens-Adamson Mfg. Co., Spherco, Sealmaster Bearing Division 178
Sturtevant, P. A., Co. 189
Synthane Corporation 74

Tennessee Coal & Iron Division, United States Steel Corporation 56, 57
Thomas Flexible Coupling Co. 168
Thomson Industries, Inc. 27, 175
Timken Roller Bearing Co., The .....Back Cover
Tinnerman Products, Inc. 78
Tomkins-Johnson Co., The 84
Torrington Co., The 13
Tri-Point Plastics, Inc. 189
Tuthill Pump Co. 141

Union Carbide Corporation, Haynes Stellite Division 80, 81
United Electric Controls Co. 195
United States Gasket Co. 160
United States Steel Corporation, Subsidiaries 56, 57
United States Steel Export Co. 56, 57
United States Steel Supply Division, United States Steel Corporation 56, 57

Veeder-Root, Inc. 200
Victor Mfg. & Gasket Co. 70
Vulcan Electric Co. 168

Weatherhead Co., The 96
Wickwire Spencer Steel Division of The Colorado Fuel and Iron Corporation 71
Wisconsin Motor Corporation 188
Worthington Corporation 68, 69

Engineers Available or Wanted 196

Fifth Conference on Mechanisms

cosponsored by Purdue University and *Machine Design*

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PURPOSE of this continuing series of Conferences is to promote better understanding, design and application of mechanisms. All designers and engineers interested in the design and development of mechanisms are cordially invited.

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MONDAY, OCTOBER 13

10 a.m.
SESSION 1—Fowler Hall—Memorial Center

EUROPEAN REPORT
Prof. J. Denavit, Northwestern University

SPACE MECHANISMS
Dr. Rudolf Beyer, professor of kinematics and mechanism design, Technical University, Munich, Germany

1:30 p.m.
SESSION 2A
Room 206
Memorial Center

Session 2A

CYCLOIDAL CRANKS
E. H. Schmidt, senior mechanical consultant, E. I. du Pont de Nemours & Co.

INFLECTION CIRCLE AND POLODE CURVATURE
Prof. A. S. Hall Jr., Purdue University

APPLYING THE INFLECTION-CIRCLE CONCEPT
Prof. James C. Wolford and Prof. Donald C. Haack, University of Nebraska

1:30 p.m.
SESSION 2B
Fowler Hall
Memorial Center

Session 2B

DYNAMIC ANALYSIS OF CAM MECHANISMS
Prof. Ray C. Johnson, Yale University

CAM TORQUE CURVES
Prof. Harold A. Rothbart, City College of New York

PIVOTED-FOLLOWER CAM SYSTEMS
Robert L. Droke, associate engineer, International Business Machines Corp.

1:30 p.m.
SESSION 2C
Room 214
Memorial Center

Session 2C

A MECHANICAL SQUARING DEVICE
Sigmund Rappaport, project supervisor, Ford Instrument Co.

MECHANICAL ANALOG COMPUTER COMPONENTS—1
George W. Michalec, section head, General Precision Laboratory Inc.

6:30 p.m.
BANQUET—Ballroom—Memorial Union Building

THE FUTURE OF AN ENGINEER
Dr. Richard W. Wallen, director, managerial training division, Personnel Research & Development Corp., Cleveland

TUESDAY, OCTOBER 14

8:30 a.m.
SESSION 3A
Room 206
Memorial Center

Session 3A

FOUR-BAR FUNCTION GENERATORS
Prof. Ferdinand Freudenstein, Columbia University

POINT-POSITION-REDUCTION
C. Wesley Allen, engineer, General Electric Co.

THE FECUND FOUR-BAR
Prof. R. S. Hartenberg and Prof. J. Denavit, Northwestern University

8:30 a.m.
SESSION 3B
Fowler Hall
Memorial Center

Session 3B

CAM-DESIGN TABLES
C. N. Neklutin, vice president, Universal Match Corp.

DISC-CAM CURVATURE
J. Hirschborn, school of mechanical engineering, New South Wales University of Technology, Sydney, Australia

HIGH-SPEED SPRING-ACTUATED CAMS
Philip Barkan, engineering research and development laboratory, Switchgear and Control Div., General Electric Co.

8:30 a.m.
SESSION 3C
Room 214
Memorial Center

Session 3C

MECHANICAL ANALOG COMPUTER COMPONENTS—2
George W. Michalec, section head, General Precision Laboratory Inc.

NONCIRCULAR GEARS
Frederick W. Cunningham, president, Cunningham Industries Inc.

12:15 p.m.
LUNCHEON—Ballroom—Memorial Union Building

THE ENGINEER'S FUTURE
J. F. Young, general manager, General Engineering Laboratory, General Electric Co., Schenectady, N. Y.

1:45 p.m.
SESSION 4—Fowler Hall—Memorial Center

MEASUREMENT AS A DESIGN TOOL
F. E. Fisher, manager, Electrical Analysis and Mechanical Analysis Lab., International Business Machines Corp.

MICROMOTION ANALYSIS VIA HIGH-SPEED MOVIES
William G. Hyzer, consulting research engineer, Janesville, Wis.

Mail to: MECHANISMS CONFERENCE, Comptroller's Office (Conferences), Purdue University, Lafayette, Ind.

233.903

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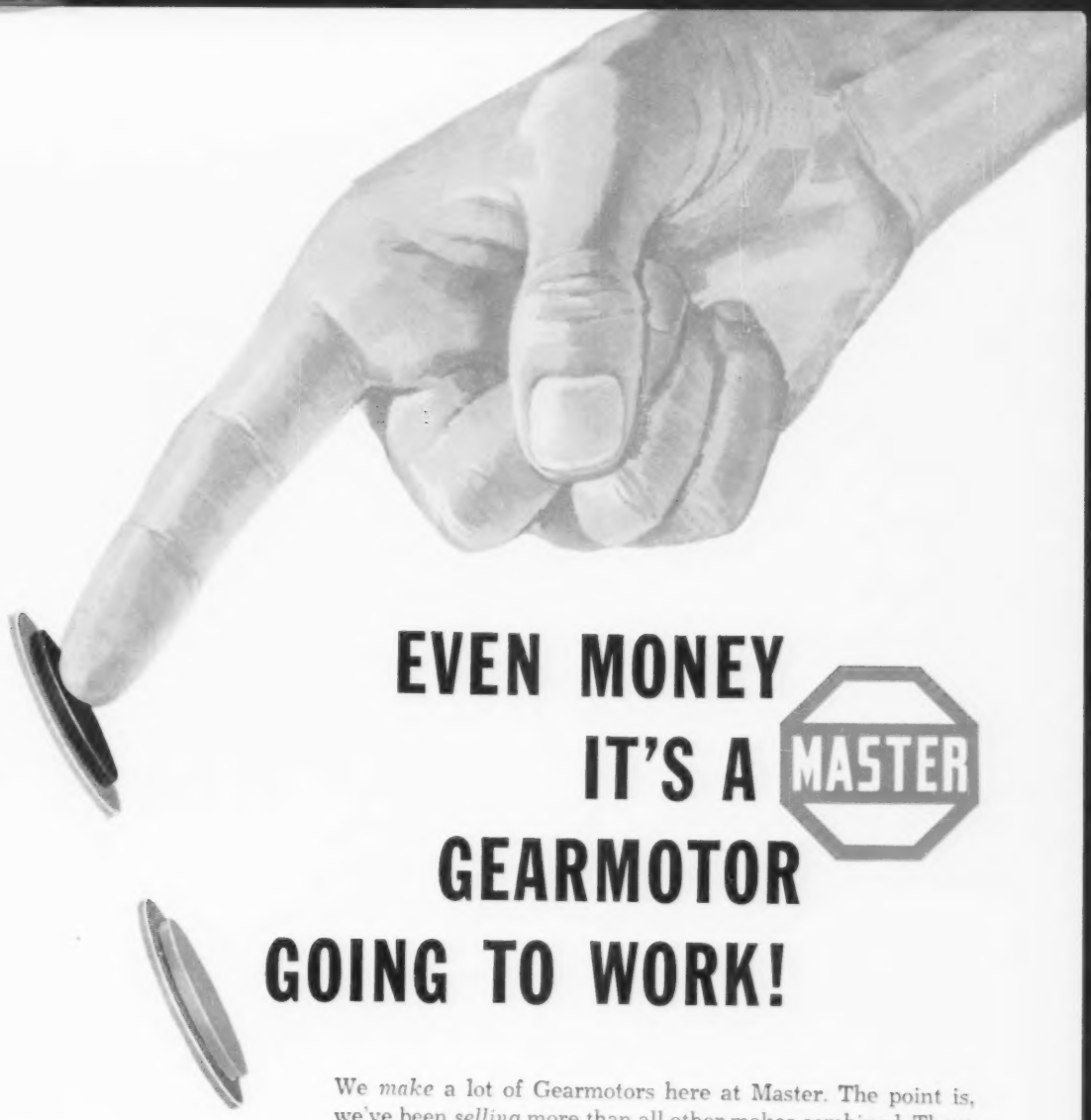
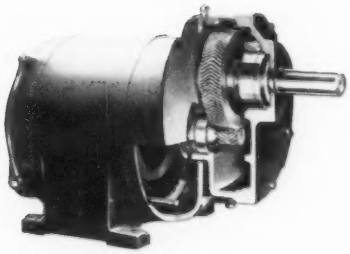


EVEN MONEY IT'S A MASTER GEARMOTOR GOING TO WORK!

We *make* a lot of Gearmotors here at Master. The point is, we've been *selling* more than all other makes combined. There are more Master Gearmotors in *use* than all others. Users *buy* more. And you don't find any foolish motor buyers—or not for long.

So it's obvious that Master Gearmotors simply must meet most requirements best. If you're not a Master Gearmotor user, now's the time to find out what you're missing!



Master Gearmotors are available with all Master motor types in right angle and parallel construction.

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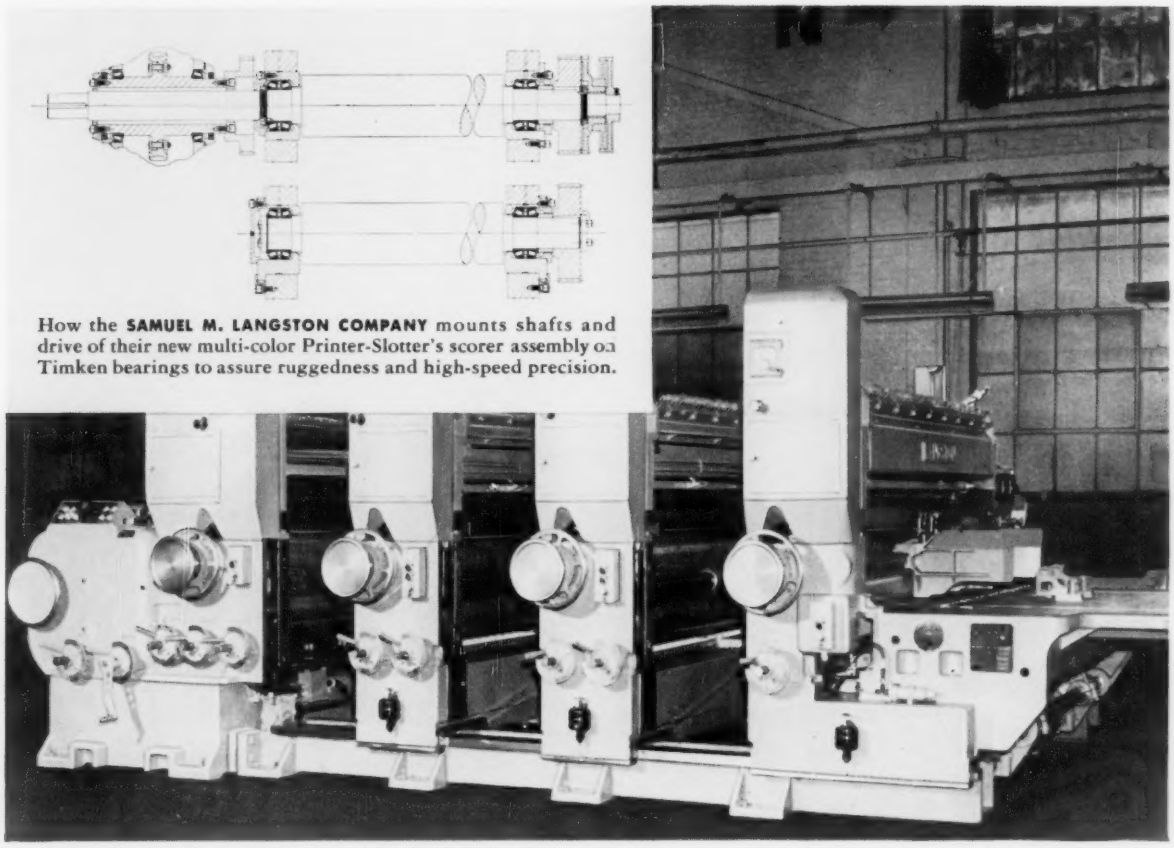
THE MASTER ELECTRIC COMPANY • Dayton 1, Ohio

DIVISION OF RELIANCE ELECTRIC AND ENGINEERING CO.

Circle 402 on Page 19

Circle 402 on Page

How the **SAMUEL M. LANGSTON COMPANY** mounts shafts and drive of their new multi-color Printer-Slotter's scorer assembly on Timken bearings to assure ruggedness and high-speed precision.



No end play, no backlash—Langston printer-slotter gives lasting precision with Timken® bearings

THE Samuel M. Langston Company designed this new *Multi-Color Printer-Slotter* to print, slot and score corrugated paperboard at high speeds. It is built for maximum precision with minimum maintenance and downtime. Langston uses 76 Timken® tapered roller bearings to insure both ruggedness and precision. These Timken bearings stop end play by holding shafts and feed rolls rigid, take the heavy shock loads. And the adjustable Timken bearings on the drive help eliminate backlash. Here's how:

SHAFTS HELD RIGID. Their tapered design lets Timken bearings take radial *and* thrust loads in any combination. No end play to adversely affect accurate register, printing, slotting and scoring. Timken bearings hold shafts concentric with their housings, making seals more effective in keeping lubricant in—dirt out.

HEAVY SHOCKS ABSORBED. Both rollers and races are case-carburized to give Timken bearings hard, wear-resistant surfaces over tough, shock-resistant cores. Full-line contact between rollers and races gives load-carrying capacity to spare.

Timken bearings are geometrically designed to roll true, precision-made from our own Timken fine alloy, electric furnace steel to live up to their design. They practically eliminate friction, run smoother, last longer.

Why not get all these advantages for machines you buy or build? To make sure you do, specify bearings trade-marked "TIMKEN". The Timken Roller Bearing Company, Canton 6, Ohio. Canadian plant: St. Thomas, Ontario. Cable address: "TIMROSCO".

This symbol on a product means its bearings are the best.

TIMKEN

TRADE-MARK REG. U. S. PAT. OFF.

TAPERED ROLLER BEARINGS ROLL THE LOAD

Circle 403 on Page 19